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SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXXVII
NUMBER 2245

★ NEW YORK, JANUARY 11, 1919 ★

Published weekly. Entered as second class matter, December 15, 1887, at the Post Office at New York, N. Y., under Act of March 3, 1879

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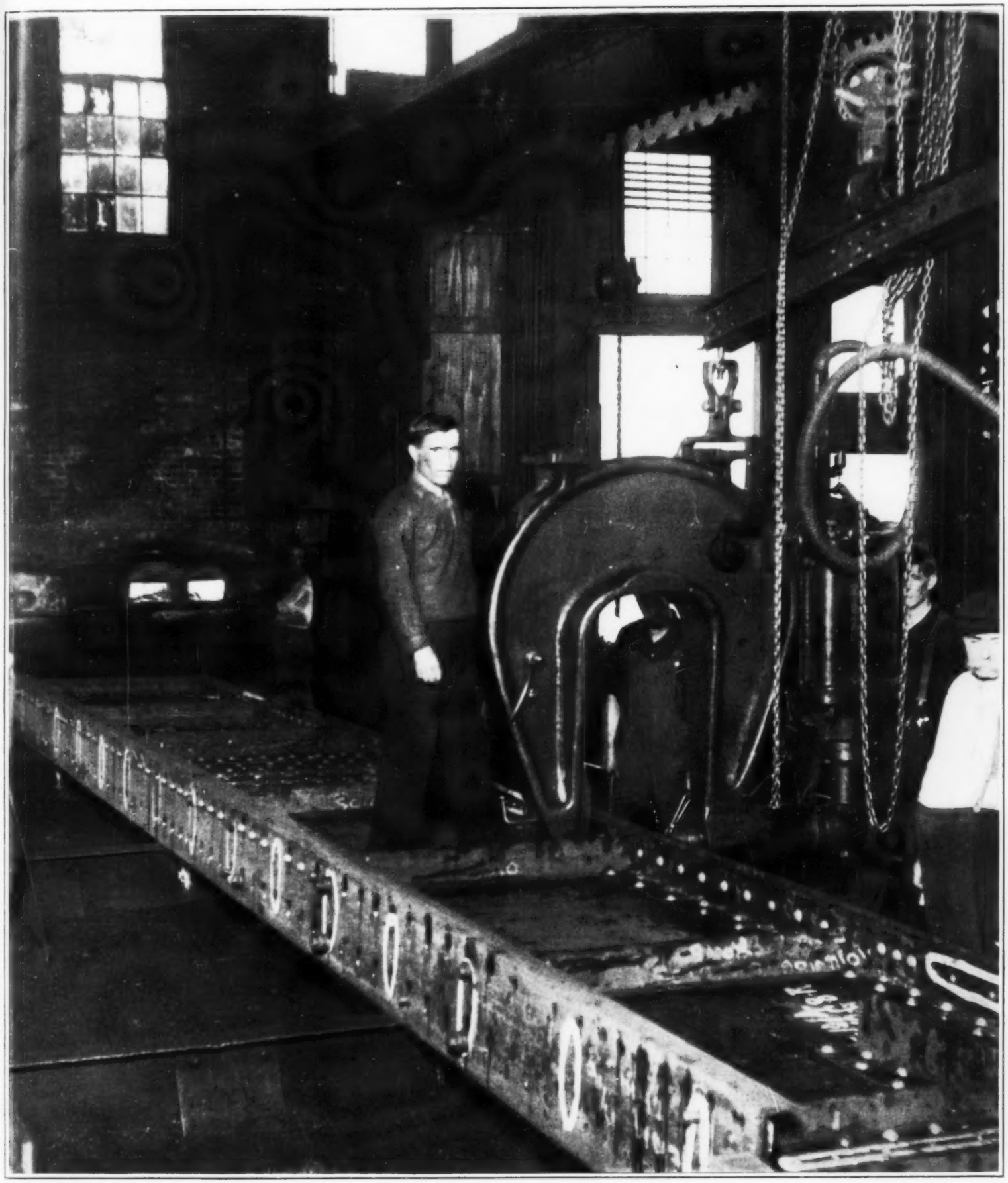

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Building up a large structural girder in a pneumatic riveting machine

STEEL FOR RECONSTRUCTION **[See page 20]**

Molecular Orientations in Physics and in Crystallography*—I

A New Hypothesis in the Investigation of Matter

By Albert Perrier, University of Lausanne

Just as the art of decoration employs as elements of composition in its most elaborate products simple designs taken directly from the objects which surround us, such as geometric figures, flowers, and other objects which remain more or less recognizable according to the degree of elaboration or the imagination of the artist who has conventionalized them, in the same way most of the ideas, images, and hypotheses employed even in the exact sciences are in the last analysis taken more or less unconsciously from our immediate surroundings; and it may be said, if you will allow me so to express myself, that here, too, the further elaboration of ideas is a matter of mere conventionalization.

Let me give you an immediate example of this, an example concerning one of the most abstract and one of the most general conceptions in physics, and not only in the physics of ponderable matter, but also in the physics of space itself: Here is a piece of wood, a substance which is compact and solid in every direction; yet the lumberman who cut it and the artisan who will make use of it are well aware that it is not a matter of indifference in what direction it is placed; if it is used for making a beam it will be placed so as to take a special direction and not another direction. In short, in this block of wood which is apparently everywhere the same, the matter which composes it presents special directions, which are made evident by peculiar properties, and this is true even if it be cut into the form of a ball and even if it is covered with a coat of varnish so that one surface cannot be distinguished from another in aspect. We see that we have here what the naturalist calls "privileged directions," and for this reason this substance which is so homogenous, but yet behaves in so variable a manner according to the direction in which it is regarded or utilized, is said to be *anisotropic*.

Again, let us consider the external aspect of perfectly pure water in a glass flask: The liquid may be in a state of absolute rest or it may have a rotatory motion without our being able to first glance to detect any difference between the two states. However, the properties, taken as a whole, are profoundly different: Any body, whatever, placed within the water, in the latter case, will be subjected to a dragging action, light and heat will not traverse it in the same manner in every direction; if the flask be poised upon a single point it will behave like a spinning top being neither more nor less erect than the latter; in short, the mere movement of the water produces a series of phenomena which were previously nonexistent, and which are all characterized, we may repeat, by *privileged directions;* thus we have created an anisotropic body and system.

The similarity of ideas between the case of the wood having fibres arranged in a certain direction and the moving water is evident; it may even be said that there is an identity from the abstract point of view . . . these two mediums wood and water are both anisotropic, or as we may also say, dissymmetrical in contrast to a block of cement or to a bowl of water or of mush at absolute rest; these latter bodies are homogeneous in all directions and are, therefore, called, *isotropic mediums.*

Very well, these questions of isotropy and anisotropy (or colotropy) which we have so readily compared in these particular objects need only be generalized, elaborated, conventionalized after the method of the artist, to yield one of the most fundamental ideas of all the physical sciences; namely, any medium in which any natural phenomenon whatever is not produced with identical intensity in every direction is a medium which is *anisotropic for that phenomenon.* We need no longer keep in mind the fibrous constitution of the wood, or the mechanical effects of a revolving liquid—we have arrived at the general idea that any body whose optical, magnetic, electric, elastic, or any other property depends upon direction, is optically, magnetically, electrically, etc., anisotropic. Moreover, all these forms of anisotropy can perfectly well exist simultaneously, in which case our body will be dissymmetrical with regard to all these properties at once.

Let us return to our two typical bodies, the piece of wood and the water, but with the idea of analyzing them more closely; let us contrast their two forms of anisotropy, the one which is the same under all circumstances, which is definitive, which belongs to the very structure and origin of the substance, that of the wood, and the other which is, on the contrary, in no way a property of the water *per se,* but which it has *acquired* by a special external action—the rotary motion; moreover, the anisotropy thus acquired is variable, it can be increased at will, and this gives us the idea of a simple classification of the various dissymmetries to be found in nature: The natural *anisotropies* which are essentially pre-existent and but little variable, and the so-called *accidental anisotropies* which we can cause at will in isotropic bodies by agents under human control—phenomena which, within the limits of power of these agents, we are able to vary, and which generally disappear with the exciting cause.

The former category, which revealed itself to the scientific mind long before the latter, comprises the properties of crystalline mediums which are essentially anisotropic by nature; as regards excited or temporary anisotropies, these have been discovered only with great difficulty, appearing at long periods of time, and it is only in the last fifty years, during which there has been a systematic study of the action of electric and magnetic fields, that the list has been really enlarged; moreover it is now being enlarged more and more every day. To support such a statement I need only remind you that it comprises among other phenomena those of electro-optics and of magneto-optics. It may be said, too, that to-day the general study of anisotropies corresponds in large measure with that of the sciences of crystallography and of physics themselves.

The explanation of the multitude of laws and of facts herein concerned has been sought in a number of hypotheses and theories regarding the structure of matter, including double refraction, elasticity, magnetism, expansion, and so forth. However, as we have seen, the ideas at the basis of anisotropy are practically identical under all their varied aspects, and any specialist who has had occasion to consider these phenomena knows that special knowledge was not necessary except for the points of departure and the interpretation of the results. . . and it is even very surprising that the close relationship between the fundamental images invoked by the theories has not been more apparent.

So far as I know there is no domain of the natural sciences which affords a more typical illustration of this logical necessity than that with which we are here concerned. If we consider the molecule as a whole it may be said that two fundamental hypotheses only have hitherto sufficed to account for the anisotropies of matter, namely:

I. Molecular reticulations (Bravais).

II. Molecular orientations.

The general hypothesis of networks or reticula is well known and the success with which it has been employed; we may recall in particular the brilliant experimental confirmation which it has obtained during the last five years through the researches of Laue, W. L. and W. H. Bragg, De Broglie, Debye and their collaborators upon the diffraction and interferences of the X-ray; and inversely the remarkable progress due to this theory in the deeper knowledge and applications of these rays; in short the theory of molecular reticulations is now considered one of the most well founded hypotheses with regard to the structure of solid matter.

It is the second of these conceptions which is the especial subject of my address today; I shall endeavor to show you how naturally it is suggested by the very idea of anisotropy, and then what its rôle has been in the development of molecular physics, and finally, the various forms it has assumed both in crystallography and in pure physics; we shall see how convenient and how effective this concept of molecular orientations has shown itself to be both with regard to natural anisotropies as well as to artificial or accidental anisotropies. We shall see how this theory successively invades the most various realms of science, and how it everywhere sheds new light along its path. By running over the phenomena which it has explained, those which it has foretold and revealed and those which it already suggests for future discovery we shall become convinced of its extreme fecundity. We shall enter realms wherein its profound reality is beyond a doubt, as well as others wherein it has been but recently introduced and will appear to be only a provisory working instrument; in these various domains this idea has unceasingly assisted in the gaining of new information with regard to molecules themselves. In all this we shall recognize an instrument of the first order with respect to scientific reasoning—an instrument which in spite of its already respectable age, since it was formulated some sixty years ago, is more modern than ever, in the best sense of the term, since it has been utilized during the last ten years more than ever before;—an instrument, finally, which renders it possible to explain a large variety of phenomena by a single basic idea. And this will justify, I trust, the attempt I am making today to give you an outline of physics in general from a special angle.

Of what then does this hypothesis consist? Our example of the piece of wood suggests an immediate answer. We have here a body which behaves differently in different directions, and this difference of behavior is evidently due to its fibers—in other words, this body, which at first sight appears to be homogeneous, is in reality composed of elements which are elongated and which are perceptibly placed *parallel* to each other, *i. e.*, in a *privileged direction.* Let us imagine for a moment that we are giants of immense size, having eyes, for example, about the size of the globe: in this case the fibres of the wood will evidently continue to play the same rôle and the wood would be no less anisotropic. But the giants observing it would perceive only the dissymmetry, and would not *see* the structural cause. Now let us change the scale: Crystallographers who perceive in their crystals directions or faces having special properties are in the same situation as are the giants with respect to the piece of wood; hence they are quite naturally led to consider these dissymetries as extending to the ultimate constituent elements, the molecules, which in this case have the same rôle as the fibres or fragments of fibres in the wood. For more than a hundred years this simple conception has been essentially the only working theory of crystallographers; to their minds the idea of oriented molecules has been far more geometrical than physical; for example, they will say that if all the molecules have the form of identical pyramids, and are arranged in a network or reticulum, the corresponding elements being all turned in the same direction, then the different faces of the crystal thus constituted will exhibit different properties—just as a block, composed of grains of wheat, placed parallel to each other, will be rougher or even harder on those surfaces which present the points of the grain than upon its other surfaces.

We shall find it quite natural, too, that crystallography should be contented with this geometric and static conception of orientation if we recall its main objects, which consist chiefly in the knowledge of external forms and optical properties, things which very readily may be described by means of geometric ideas, and if we remember, too, that with regard to material structure crystallography is mainly engaged in investigating the figures which form the networks of molecules for each srystal, and not in studying the properties of the structure of the molecule itself. But when we speak of orientations which are perceptible externally we imply, at the same time, a dissymmetry in the molecular edifice itself, and it is the physicists who are especially preoccupied with these intramolecular problems. Furthermore, the crystallographers have as yet bestowed but little attention upon the forces which support the structure of networks, and consequently almost as little upon the properties of the molecules themselves. Let us leave, for a few moments, these ideas of the crystallographers, though we shall soon return to them in a roundabout way, and see what was going on meanwhile in the camp of the physicists.

It is intentionally, and I believe quite properly, that I separate these two developments of the same theory, one in crystallography the other in physics. For in the first instance these two kinds of researches, although both are applied to related problems, are in reality followed quite independently, ignoring each other almost completely, as unknown to each other, we may say, as the waters of two rivers springing from the same mountain side and flowing towards the same sea, but emptying into different basins; and, furthermore, the nature of the question was almost separated by the very classification we have found, since natural anisotropy chiefly engages the interests of crystallographers

*An abstract of an address given before the Helvetian Society of Natural Sciences at Zurich, Sept. 10th, 1917, and published in the Minutes of the Swiss Society of Scientific Research, 1917, vol. II.

while temporary anisotropies, on the contrary, occupy the attention of physicists almost exclusively. Finally, the explanations being clearly defined on both sides, we are better able to appreciate at its proper value the theory which has succeeded in explaining, for the first time, both natural and accidental anisotropies clearly and precisely by the same mechanism.

To start with, the first phenomenon which suggests to physicists that it may be explained by the hypothesis of orientation is a temporary anisotropy, namely, the phenomenon of *magnetization*. A magnetized body is, in fact, in the sense in which I have chosen to use the word, the seat of an accidental anisotropy, which can be produced or destroyed at will, or which can be augmented or diminished.

In 1821, Poisson enunciated the theory that under the influence of an external magnetic force each molecule becomes a little magnet. In 1850, Weber offered a different interpretation of this phenomenon, according to which in any state of a magnetizable body each of its molecules is a permanent magnet to begin with, *i. e.*, a body having two poles (north and south). If, however, all the positions are represented the body will not appear to be more positive than negative upon any portion or at any point of its surface, it will be *neutral*. But if an external action comes into play, then, if the molecules possess a certain degree of mobility, in spite of the structure of the body, they will gradually turn in the same direction, and little by little one side of it will become positive and the other negative. The more energetic the controlling action becomes the more complete will be the parallelism of direction and the more highly magnetized the body will be. When the external force disappears the small magnets will regain their former position to a greater or less extent, and the body will remain more or less magnetized correspondingly.

Precisely here we find the contrast with the conception of the crystallographers, according to which we have to deal only with molecules completely oriented or not at all so; but in this other view the molecules are mobile, are not at all aligned in networks, and are more or less orinetable at will; in both cases, however, *the dissymmetry of the molecule itself is a necessary postulate*. This gives us an extremely simple image by which to explain the variable dissymmetries of an ensemble; in fact this hypothesis of Weber, with certain improvements in detail, has successfully guided researches in magnetism for half a century; it has been confined, however, to the restricted field of ferromagnetism, and even there we have had to content ourselves with qualitative explanations.

About a dozen years ago immense progress marking a new stage in the theory of temporary orientations was achieved—I refer to the introduction of the theory of what physicists term *thermic agitation*. To begin with, this enables us to find a quantitative explanation of paramagnetism, and secondly it makes possible surprising generalizations of phenomena which are apparently singularly remote from each other.

Today we are obliged to believe that molecules are endowed with a continual motion which is extremely varied, capricious, rapid, even violent; in gases and liquids these movements have now been directly demonstrated by the Brownian movement among others; in solid matter, while we are obliged to exclude movements of translation, everything leads us to believe, on the other hand, that the molecules are not less agitated by oscillations or rotations than they are in gases. And all this apparent disorder is dominated by one great law: The *energy of these movements is primarily approximate to the absolute temperature*. In less abstract language the warmer a body is the more violently agitated are its molecules.

Accepting the theory of M. Langevin,[1] we attribute this supplementary property to our small molecular magnets. We can thus readily imagine the general course of the phenomena in question: A molecule progresses in any given direction only for a very brief instant, but travels successively and irregularly in every possible direction, and it may be said that altogether this thermic agitation produces a perpetual stirring up in different directions which constantly tends to destroy and temporarily established order even in a solid body; consequently a magnetized body will always have a tendency to demagnetize itself of its own accord. For this reason some external form of uninterrupted action is required to maintain a certain degree of *average* orientation, and this play of natural forces may be regarded as a ceaseless struggle between the powers of order—the agents of orientation, which may also be something other than magnetic fields, and the thermic agitation which is a disordering force. Finally the orientation will be on the average the more complete the more powerful the agent of order is, and less so, on the contrary, the more violent the agitation to which they are subjected, *i. e.*, *the higher the temperature*.[2] (Fig. 1.) In this manner Langevin has discovered a remarkably lucid explanation of the law of Curie to the effect that paramagnetic susceptibility is inversely proportionate to the absolute temperature.

Since I am not here especially concerned with magnetism I will only remark in passing that this theory

Fig. 1

has, during the last few years, supported and guided investigations which are impressive not only in their numbers but even more so by the richness of their results, both as to phenomena and as to the realm of the molecules.[3]

Temporarily, therefore, let us turn aside from magnetism and give our attention to a field which at first sight seems completely foreign thereto—I refer to optical anisotropies, which are, of course, accidental or imparted anisotropies. It has long been known that bodies which are perfectly isotropic in themselves (such as glass) are capable of temporarily exhibiting the phenomenon of double refraction, in other words, of behaving like crystallized bodies; for example, this phenomenon may be produced merely by changing the form of the glass. But it is possible to observe similar modifications of matter caused by purely electrical means: for example, not only glass but many liquids and some gases interposed between two Nicol prisms crossed to extinction will reproduce the light with fringes of interference when acted upon by the poles of a high voltage electrical machine. Accordingly, these bodies become temporarily doubly refractive, and the direction of the electric force of the field is the privileged direction acting like the axis of the crystal. This was the beautiful discovery made by Kerr some thirty years ago; I will return to this explanation, but I prefer first to describe the parallel phenomena produced by magnetic forces. We have only to replace the poles of the electrical machine by those of a powerful electro-magnet and again we shall observe a series of isotropic bodies assuming the optical properties of a crystal with an axis, the axis being the direction of the magnetic field; this action has been discovered much more recently by Majorana in the colloidal solution of salts of iron. These phenomena remained almost isolated for so long a time that no explanation was found to conveniently form a connection between them, though various interesting theories were proposed referring either exclusively to the interior of the molecule or to the rudimentary formation of the networks.

In a remarkable series of investigations covering several years Cotton and Mouton[4] selected this hypothesis of orientation (entirely novel in its application to this field)—the orientations, that is, either of granules suspended in colloids or of molecules themselves in pure liquids. Thus, in the opinion of these authorities the electric field and the magnetic field produce the same effect upon the molecule, an average slight change of direction, the optical effect being a secondary result of this orientation and we are no longer astonished that it should manifest itself in the same fashion in these two cases which are so different from each other; a complete theory based upon this hypothesis was published later by Langevin.[5]

The studies of Cotton and Mouton have brought to light an impressive number of new facts and lucid laws; the discovery of the magnetic double refraction of a large number of pure liquids, and particularly of those of the aromatic series, is alone sufficient to classify these and also to exhibit the fecundity of the theory adopted by them; none of the results obtained fails to accord with the theory, while many of them lend it very solid support. I will cite only the single fundamental point to which we will return again and again: mainly, the fact that the phenomenon becomes less manifest as the temperature rises, which indicates, as in the case of magnetism, the presence of thermic agitation. And the questions raised by the theory now form the object of numerous investigations in the laboratories of both the old world and the new. Furthermore, it is evident that all these acquisitions of facts have helped to enrich our knowledge regarding the structure of molecules; more in this field indeed than in others, since if orientations intervene in double refraction the molecule must necessarily exhibit not only optical but electrical and magnetic dissymmetries. The measuring of the phenomena observed will enable us, therefore, to measure these various characters and to gain an approximate idea of their causes.

I find it desirable at this point to call attention to the fact of how much of intuition and of audacity was required to apply a theory similar in its directing idea to that of magnetism to substances (organic compounds in particular) in which the reactions properly called magnetic are almost imperceptible, and which are furthermore, precisely the *inverse* of those which iron and its compounds present, since they are diamagnetic.

And this daring intuition opens for us a path which we might have hesitated to enter, that is, the explanation of the exact electrical analogy of magnetization by influence, the polarization of dielectrics; for, in fact, to accept as the cause of electrical double refraction a parallelism of electrically dissymmetrical particles is the same thing at bottom as the replacing in the theory of magnetism the magnetic poles of molecule by electrical charges, and consequently causing the appearance of *electrical* charges upon the surface of the body; consciously or not we have at the same time introduced orientations into the theory of dielectrics. This idea has been pursued independently by P. Debye and J. J. Thomson.[6] However, this adaptation of the theory of magnetism is more complicated than this last, for here the theory of Poisson, modernized by Lorentz, certainly contains some truth: namely, that the polarity of the molecules depends upon the external action, and that that which we obtain is the resultant effect of the latter and of the orientations. As yet we are not able to affirm that this recent theory will prove applicable in a great number of cases, but it alone, up to the present time, has taken into account the thermic variations of dielectric constants, has been the basis of various interesting investigations and will direct others whose primary object will be to decide its own legitimacy.

[TO BE CONTINUED.]

[1] Langevin. Annals of Chemistry and Physics (8) 5, (1905), p. 70.

[2] To illustrate as directly as possible the effect of thermic agitation I have made use of the following experiment, which can be readily exhibited before a large audience, and which occurred to me while examining the magneto-kinetic researches of H. du Bois (Amsterdam Academy, 10, 1902, pp. 415 and 506). A small magnetized steel arrow (Fig. 1), pivoted at its centre within a stirrup which permits it to take all possible positions between 0° and 180° in a vertical plane. The stirrup itself forms the extremity of a vertical axis to which can be imparted by any convenient means a revolving motion, whose speed is variable at pleasure. At the same time the arrow is placed in the field of the pole of an electro-magnet placed beneath it. It is manifest that the action of the field and that of the rotation will be opposite to each other, and that the arrow will describe a cone whose orifice will increase in direct proportion with the number of revolutions, and will diminish when the field is augmented. This experiment must be carried out with great precision to ensure success.

[3] See in particular the researches upon paramagnetism of H. du Boih, G. Foex, K. Honde, H. Kamerlingh Onnes, W. H. Keesom, E. Oosterhuis, M. Owen, A. Perrier, P. Weiss, etc.

[4] Cotton and Mouton, Annals of Chemistry and Physics. 11 (1907), pp. 145 and 289; idem, 19 and 20 (1910), p. 194.

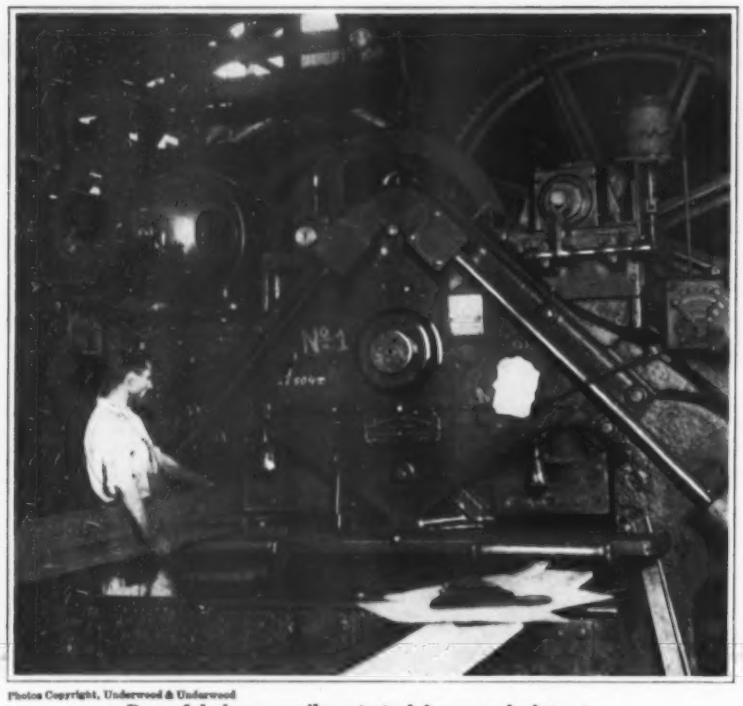
[5] Langevin, Radium 7 (1910), p. 249.

[6] P. Debye, Phys. Zeits. (Physical Jurnal), 13 (1912), p. 97, and J. J. Thomson, Philosophical Magazine (6), 27 (1914), p. 757.

Impurities in Gun Metal

MR. F. JOHNSON, at a recent meeting of the British Institute of Metals, gave the results of some exploratory work undertaken with the object of ascertaining which element or elements show promise of utility in the manufacture of Admiralty gun-metal castings, which exercise a benevolent neutrality, and which are actually detrimental.

Nickel had a decidedly beneficial effect, and a remarkable increase in ductility was obtained. Lead did not appear to affect the mechanical properties seriously, though possibly the resistance to shock are lessened. Iron had a beneficial effect on mechanical properties, yield point, tensile stress, and elongation all being raised. Its effect on pouring qualities was bad, but much improvement in this respect was effected by the addition of a trace of aluminium. The influence of manganese was bad in every way. The mechanical properties and the pouring qualities were adversely affected, and the surfaces of the castings were bad. Annealing treatment was found to go far towards eliminating the ill-effects produced by undesirable additions, notably aluminium and silicon.—*London Times Engineering Supplement.*



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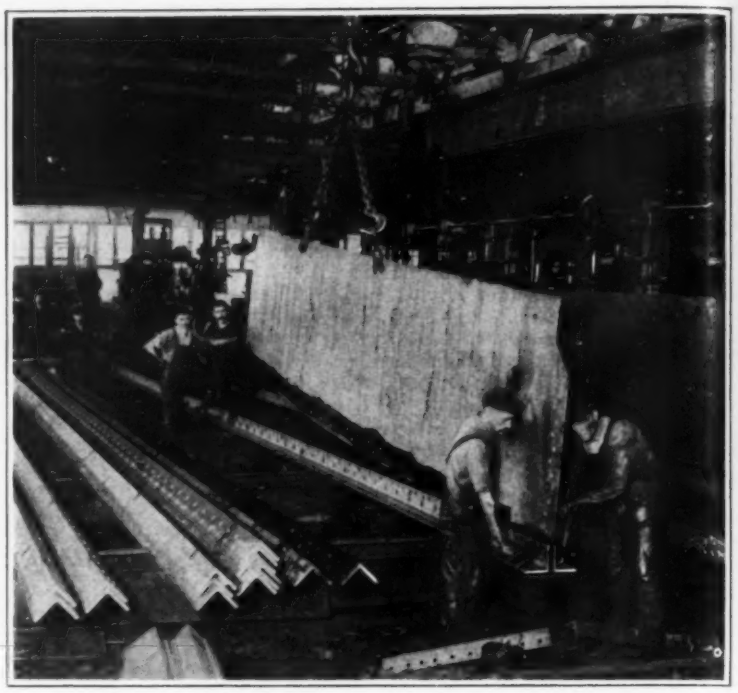
Powerful shears easily cut steel forms and plates to shape and size



Here the workmen are assembling the angle bars and plates to form a large girder

Steel for Reconstruction

EVERYONE knows how vast the ravages of war have been, and of the enormous destruction of property, particularly in Belgium and a large section of France. Buildings, factories, bridges and railroads, with everything appertaining to them, have been obliterated, only to mention a few of the important consumers of materials; and all of these must be replaced as rapidly as possible. Not only this, but the entire world is four years behind in the normal construction required to keep up with the demands of constantly increasing population, and this shortage must be made up as well as the replacements caused by war losses.

In this work of rehabilitating the industries of the world the material most universally required is steel, of which vast quantities will be needed, and for this the world looks to America, which is now the largest producer, particularly of structural material, which is the particular description most in demand. The accompanying illustrations show a few of the operations in American shops engaged in turning out structural steel work, and in this branch of production our great establishments are not equalled anywhere.

Of course a large amount of damaged material will be salvaged in the countries that have been the scene of German destructiveness, a destructiveness not dictated by the necessities of war alone, but carefully planned with a view to the future commercial advantage of Germany; but all of this must be worked over, and this will take a long time, especially in view of the fact that all plants doing this kind of work in Belgium and France have been utterly destroyed. It is therefore evident that our big steel works will have all they can possibly do for a long time to come, notwithstanding the great additions to their facilities that have been made during the last few years. And in addition to all of these vast demands on our resources great amounts of steel will be required to complete the extensive shipbuilding program that is now being carried out. There is, however, a bright side to the prospect of these years of activity in one of our largest fields of enterprise, and that is that the material prosperity that should result will greatly aid in bridging over the period of our own commercial reconstruction, to the time when business will again rest on a sane, substantial and conservative basis.

A New Photographic Mordant Dye Process

By Frederic E. Ives

THE first photographic mordant dye process to attract attention was the silver-iodide process of Dr. Traube (U. S. Pat. 1,093,503, 1914). Metallic silver photographic images converted to silver iodide and immersed in solutions of basic dyes become strongly colored. If the dye is then fixed by tannin, the silver-iodide can be dissolved out, leaving a transparent dye image. Traube's method was improved upon by Tauleigne and Mazo (U. S. Pat. 1,059,917, 1913), who showed how to produce a silver-iodide image having a stronger affinity for the basic dyes, and incidentally that by first hardening the gelatine with alum and then treating the silver-iodide image with a strong solution of potassium iodide it was made so transparent that for most purposes it was unnecessary to dissolve out the silver-iodide image. The step of hardening the gelatine in alum to prevent it from softening and dissolving in the strong potassium iodide solution was omitted in the United States patent specifications, but was published in the *British Journal Photographic Almanac*, 1912, page 653. Hoyt Miller (U. S. Pat. 1,214,940, 1917), as a result of experiments with the process without hardening, declared the process unworkable, and broadly claimed the production and dyeing of a transparent silver-iodide image, he hardening the gelatine with formalin. I have myself operated the Tauleigne-Mazo process with perfect success.

Incidentally it had been discovered that silver ferrocyanide, silver chromate and some other silver salts could be similarly dyed, but not with satisfactory results. Fox (U. S. Pat. 1,166,123, 1916), disclosed the fact that a vanadium-toned silver image mordanted basic dyes, and Crabtree and Ives (priority to Crabtree) independently discovered that a copper-toned image had the same property to a very notable and useful degree. The copper-toned image, like the transparent kind of silver-iodide image, is sufficiently transparent for most purposes without "fixing out," but can be made perfectly transparent by fixing "hypo" without first fixing the dye image with tannin. It has the disadvantage for some purposes that the copper-ferrocyanide image is itself colored (red-brown) and will not serve as the base for pure blue and green images. It has proved perfectly satisfactory for the production of orange-red images in combination with a cyanotype print in the same colloid layer in my colored moving picture process (U. S. Pat. 1,278,668, 1918).

Before shipment, all structural steel is given a coat of paint to protect against rust

Recently, I have discovered a new method of producing mordant-dye photographic images, which I think is superior to any heretofore known. The mordant is a chromium compound the exact nature of which I have not yet determined, but it is not silver chromate, which is of a deep red color, while the image which I produce previous to dyeing is of a very pure, though pale, yellow color. It is produced very simply, quickly and cheaply, by bleaching the silver image in a solution of equal parts of potassium ferricyanide and chromic acid, the action of which is analogous to that of potassium iodide in that if the solution is weak the image is not transparent, but if the solution is strong, the image is perfectly transparent and of a pale, though pure yellow, color. It is necessary to wash out the free chromic acid after bleaching. The pale yellow image thus produced has a much stronger affinity for some of the basic dyes than either silver iodide or copper ferrocyanide. In fact, the silver image, for the best results, must be thin and superficial.

My bleaching solution is made with one ounce each of potassium ferricyanide and chromic acid in one gallon of water, at which strength it acts very quickly and produces a transparent yellow image. Transfer to running water should be made immediately when the image is completely bleached to avoid overhardening of the gelatine by the chromic acid. Long washing is necessary to clear out the free chromic acid, but it discharges rapidly in water containing a little soda bicarbonate, and the image also dyes up quicker and clears more rapidly after dyeing if the soda bicarbonate is used. I always use it, but too long immersion whitens the image, reduces its transparency and produces a weaker, though still strong and brilliant dye image.

A typical dye bath is made by dissolving 10 grains of saffranin in 4 ounces of alcohol and adding it to one quart of water made slightly acid with acetic acid. For complete dyeing, an immersion of half an hour or more may be necessary. This will stain the entire film deeply, after which it may be cleared by washing in water containing a very little acetic acid. Other very active dyes are malachite green and auramine.

The images which have been whitened by long soaking in soda bicarbonate solution have the same appearance and transparency as silver ferrocyanide images, but have many times more mordanting power—more even than silver iodide.—*Note from the Hess-Ives Laboratories in the Journal of the Franklin Institute.*

A Meat Substitute in Germany

YEAST is used in Germany as a substitute for meat. It is easily absorbed, very nutritious and can be made quite palatable. It has been found to be bad for people with rheumatic or gouty tendencies.—*Med. Sum.*

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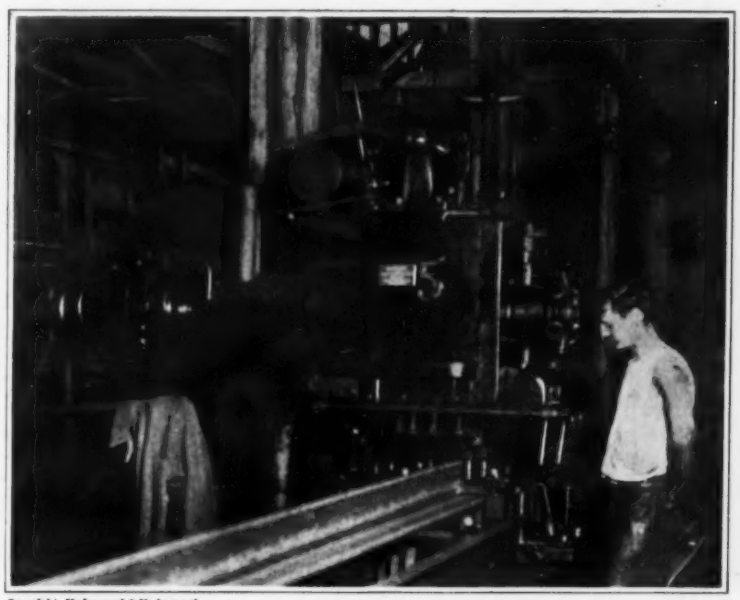
Long rows of drilling machines quickly bore and ream the numerous holes in structural parts for buildings and ships



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Innumerable holes are necessary for connecting the parts that go to make up the parts for buildings and standarized ships

The Rat Pest

REFERRING to Prof. P. Chavigny's report on rats in the trenches (SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 2234-5), Mr. C. B. Moffat, Enniscorthy, points out that the descendants of a pair of rats must in three years far exceed the twenty millions stated. At the end of the first year there should be 50 offspring, 500 grand offspring, 1,000 great-grand offspring, 1,250 great-great-grand offspring—2,800 in all. Half of this number, supposing females equal males, multiplied by 2,800, gives 3,920,000 at the end of the second year. At the end of the third year the number should be far more than five thousand millions. It has to be borne in mind, however, that female rats probably reach their limit or menopause long before three years. The most secure data known to us are those of Helen Dean King (*Anat. Record*, vol. xi., 1916, pp. 269-87) on 76 females derived from a cross between the wild Norway rat and the domesticated white rat. The average number in a litter was 6.7 (Prof. Chavigny speaks of 10); the average total number of litters for a female was 7.7; there is a sharp decline in fertility after the female is a year old, and the menopause appears at eighteen months. The sex ratio for 3,955 individuals was 106.1 males to 100 females. We do not know how Prof. Chavigny reached the figure twenty millions, but, as Mr. Moffat recognises, there are various biological considerations which make the computation not so simple as it seems at first.

Without doubt, the most thorough and informative summary of the menace which faces us from the hordes of rats and mice in our midst has just been issued by the Trustees of the British Museum (Natural History), forming No. 8 of the Economic Series issued by that institution. The author, Mr. M. A. C. Hinton, one of the greatest living authorities on this subject, has marshalled his facts with extraordinary skill; so much so that he has contrived, within the space of some sixty pages, to pass in review, not only the life-history of these pests in a state of nature, their relation to public health, and their amazing destructiveness in the matter of our food supplies, but also the various preventive measures which afford us means of relief. On this head he has much to say in condemnation of the destruction of so-called "vermin," which, until now, has been so persistently and stupidly followed. Finally, he adds a most valuable chapter on the classification of the Muridæ, and a table showing the assumed rate of increase in the annual rat population, which, even while postulating a mortality which is purposely exaggerated, shows clearly enough that none but the most determined efforts can hope to lessen the seriousness of the situation, which has come about owing to the withdrawal of all labor hitherto devoted to the destruction of rats, either by the needs of the Army or by the allurement of the high wages paid for other kinds of work more or less directly arising out of the war. This pamphlet should be carefully studied, not only by the agriculturist, the merchant, and those responsible for the preparation of food in restaurants, but also by the housekeeper; for it is only by the concerted efforts of us all that we can hope for success in this campaign, which is now to be commenced against a condition of affairs which is fraught with real peril.—*Nature.*

Prune Cultivation in France

THE cultivation of the prune in France is said to have been started at Clairac, in the Department of Lot et Garonne, by monks of that region. The principal varieties now grown are the prunes d'Ente, prunes d'Agen, and prunes robe de Sergent. Formerly the prunes du Roi and prunes Saint Antoine were also cultivated, but these varieties have been largely discontinued because they are more difficult to cook.

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Twisting square steel bars to be used for reinforcement in concrete work

For processing, the fruit should be quite ripe before gathering. This fruit, especially the prune d'Ente, is generally found in the best condition for use in September. It seems preferable to let it ripen and fall naturally, as it is then easier to preserve, richer in flavor and color, and heavier in weight.

If the fruit remains too long on the tree it is shaken down, but to prevent injury straw is spread under the tree, or the ground is softened. The prunes must be pick up promptly, at least once a day under each tree. They are then spread out for a day or two in a dry place, and afterwards placed in ovens, to complete the drying. Formerly bakers' ovens were used, but others specially suited to the purpose have now been made. Three periods in the ovens are necessary, the first two to remove all the water in the prune, and the third to cook it. During the first period the temperature must not exceed 45° to 50° C. (113° to 122° F.), during the second period, 65° to 70° C. (149° to 158° F.), and it is said to be very important that the temperature should not exceed the latter mark. After each of these periods the fruit must be exposed to fresh air, and it is necessary to avoid disturbing the fruit while it is warm. The third period, to cook the prune, must have a temperature of 80° to 90°, or even 100° C. (176° to 194°, or even 212° F.). This operation must be conducted carefully to avoid burning the fruit. The length of each period depends upon the condition of the prunes, but is generally about six hours.

The prunes are next separated into eight classes, or grades, depending on the size of the fruit. The class is determined by the number of prunes necessary to make a French pound of 500 grammes (1.1 lb.). Prunes of the superior first grade require but 30 to 35 to the French pound, while there are 40 to 45 of the ordinary first grade; second grade, 50 to 55; third grade, 60 to 65; fourth grade, 70 to 75; fifth grade, 80 to 85; sixth grade, 90 to 95; seventh grade, 100 to 110; and eighth grade, 120 to 125.

The prunes are usually packed in wooden cases of 14 kilogs 200 grammes (31.2 lb.), having a net weight of 12½ kilogs (27½ lb.) For South American trade, cases of 50 kilogs net (110 lb.) are sometimes used, but only for the lower grades of fruit. Decorated tins of a half kilog (1.1 lb.) and glass jars are sometimes also used to cater for special demands, but at present special containers are too expensive for profitable use.

Rubber-Seed Oil

THE report of the Federated Malay States Agricultural Department shows evidence of the growing tendency to apply scientific methods to the rubber industry. A description is given of the method of manufacture of rubber-seed oil and its residual product with a view to putting it on a commercial basis. It would seem, from the report, that this high-grade oil requires hardly any refining, is obtained from a waste product available in great quantity, easy to collect, transport and store and easy to crush. It would certainly pay in normal times to ship the seeds or kernels but, as the prospects of freight facilities for some years do not present a bright outlook, it would seem that shipping the oil is the better proposal. Oil keeps better than seeds and is more easily stored. Experiments with a consignment of 30 tons of seeds sent to England resulted in $250 per ton being obtained for the oil, while $40 per ton was realized for the residual cake. At the time linseed oil stood at $300 per ton. The difference of $50 per ton may be put down to the prejudice with which all new products have to contend. As far as can be foreseen, rubber-seed oil will soon occupy a place but little inferior to linseed oil.—*Jour. Ind. and Eng. Chem.*

The Pharmacology of Alcohol*

A Powerful Drug the Action of Which Has Not Been Fully Determined

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I INTEND to confine myself to the pharmacological action of alcohol in the narrow sense of the word pharmacological and to consider the action of alcohol as a drug. The actions and uses of alcohol in medicine may be summarised under four heads: (1) Local action on the skin, mucous membranes, and raw surfaces; (2) reflex actions on the body when applied to accessible mucous membranes; (3) action on digestion; and (4) actions after absorption into the blood.

LOCAL ACTION OF ALCOHOL ON EXTERNAL SURFACES.

Its action on the external surface depends upon its volatility, its affinity for water, its power of coagulating proteid, and its antiseptic action.

Owing to its volatility it is an almost invariable ingredient of cooling lotions when allowed to evaporate freely from inflamed surfaces. Somewhat paradoxically the same property determines its inclusion in most liniments and other preparations intended to irritate the skin, for when the alcohol is not allowed to evaporate the vapor easily penetrates the skin and irritates the sensitive and highly vascular tissues beneath the horny epidermis. Its affinity for water causes it to harden the tissues by extracting water from them, and this hardening effect is increased by the coagulation of the proteid in the still unkeratosed or partially keratosed cells of the deeper layers of the epidermis. In a more dilute form the same properties are used in astringent gargles and lotions.

The antiseptic properties of alcohol are responsible for the existence of a great part of our museums of natural history, anatomy, and pathology, and although inferior in degree to many other antiseptics they add largely to its value as a local application. The fact seems too little known that the most powerful antiseptic effects are produced, not by absolute alcohol, but by alcohol of from 40 to 70 per cent.[1]

REFLEX ACTIONS OF ALCOHOL.

The reflex actions which follow the local application of alcoholic solutions of a strength of 20 to 25 per cent. or over to the mucous membrane of the lips, mouth, and pharynx are of considerable importance because it is largely to these actions that alcohol owes its popular reputation as a stimulant. Its action is that of a local irritant and on a par with the action of ammonia or strong acetic acid and many other volatile irritants. The effects observed are a rousing of the latent consciousness, an increase in the movements of respiration, an increase in the force and frequency of the heart—in short, a hastening of the recovery.

That these results are reflex is shown by the fact that they begin at once, long before any of the alcohol can have been absorbed; that they occur even when none of the drug is swallowed but merely retained for a short time in the mouth and then rejected; that they are proportional to the strength of the alcohol and not to the quantity, a few drops of strong alcohol merely applied to the lips is often effective, while a considerable quantity of dilute alcohol produces little effect, even if swallowed; finally, they do not occur if alcohol is injected directly into the circulation in animals.[2]

The effects are also of a very temporary character and pass off in about ten minutes unless the alcohol is swallowed, when they may persist for half an hour, probably owing to the additional reflex from the mucous membrane of the stomach. I think much confusion has been caused in the discussions upon the action of alcohol by the failure to distinguish sharply between these reflex effects common to all volatile irritants and the effects of alcohol after absorption.

THE ACTION OF ALCOHOL ON DIGESTION.

The action of alcohol on digestion is made up of two factors—viz., its action on the stomach and its action upon the stomach contents. The former is a combination of its local action on the walls of the stomach with the effects of its reflex action; the latter is purely chemical and due to the action of the drug upon the gastric secretions and upon the constituents of the food.

It appears to be established that in dilutions up to 5 per cent. no deleterious effects are produced upon the action of the digestive ferments, nor any hardening of the proteid food which would make it more slowly digested. In this dilution the activity of gastric digestion is increased (1) by the action of the alcohol upon the mucous membrane of the mouth and pharynx, causing a reflex flow of saliva and gastric juice; and (2) by its local action upon the mucous membrane of the stomach, causing increased vascularity and a further flow of gastric juice.

The stomach is practically a closed cavity with a temperature of 98.6° F., and no matter how dilute a solution of alcohol may be, the alcohol will be partially vaporised at this temperature, and that part of the stomach unoccupied by food will contain a comparatively concentrated alcoholic vapor which is a marked irritant to a delicate mucous membrane. I believe this is the cause of the feeling of warmth in the stomach which usually follows the taking of even small quantities of alcohol, and that it is the vapor rather than the alcohol in solution which acts as an irritant and causes the increased vascularity. The rapid absorption of alcohol from the stomach—as compared, for example, with water—is probably also due, in part, at any rate, to the alcoholic vapor diffusing rapidly through the delicate epithelial cells of the mucous membrane.

In concentrations over 5 per cent. almost all observers are agreed that alcohol delays digestion by interfering with the action of the digestive ferments and possibly hardening the proteids of the food, while strong concentrations set up an actual catarrhal inflammation of the stomach, as was demonstrated many years ago by Dr. Beaumont in the classical case of Alexis St. Martin.

The increased movements of the stomach supposed to be set up by alcohol and so aid digestion have not been demonstrated by the more recent experiments, and it is doubtful if they occur in the case of dilute solutions. In certain concentrations, however, alcohol acts like a volatile oil, regulates peristalsis, relieves spasmodic pain and removes flatulence.

ACTION OF ALCOHOL AFTER ABSORPTION.

It is now universally admitted that the main action of alcohol after absorption is on the central nervous system, and I think it is also admitted that the action of large doses is always a depressing or paralysing action. The various centres are affected in the inverse order of their development so that the first to go are the highest centres of judgment and emotional control, comparison, and inhibition. Those inhibitory centres which are so constantly in action in all civilised communities to restrain the inclinations and impulses of the natural man are early affected, and as civilisation becomes more complex and life more intricate, these inhibitory centres are sometimes strained to breaking point. In such cases alcohol may benefit a patient by giving his inhibitory centres a rest and time for recuperation. Released from the habitual control of the higher centres the lower centres tend to become more purely reflex and to over-act in response to various stimuli, giving rise to that increased activity, muscular or emotional, which, together with the reflex effects already considered, is responsible for the popular conception of alcohol as a stimulant. As the action of the alcohol proceeds these lower centres are themselves paralysed and the paralysis spreads to the still lower motor centres, then consciousness itself is lost and the full action of alcohol as a narcotic poison is manifested.

The question is, however, more difficult in the case of the small doses of alcohol usually given for therapeutic purposes. The study of the various published researches leads me to the conclusion that so far the case for any preliminary stimulant action of alcohol on the central nervous system is not proven, and that all the phenomena attributed to such action can be equally well explained by assuming the action of alcohol to be consistently depressing throughout.

I cannot now go into the subject of the anatomical basis for the action of alcohol upon the brain cells—whether it is directly upon the cell protoplasm itself, or in combination with the lipoids of the brain cells, or upon the dendrites so as to interrupt communication of impulses from neuron to neuron; any or all of these hypotheses are possible. It appears, however, to be certain that the neurons of centres having certain functions are more sensitive than others, and probably the relative sensitiveness of the centres may vary somewhat in different individuals. With small doses, not sufficient to cause noticeable excitement, painful sensations are less acute and sources of mental worry, anxiety or irritation no longer occupy so large a place in the field of consciousness; there is consequently a feeling of euphoria or general well-being and a tendency to drowsiness or actual sleep if the environment is favorable. It is this sedative influence which is often so valuable in dangerous and exhausting illness, and the judicious use of alcohol may suffice to turn the balance in a debilitated and despairing patient. I wish to lay stress on the fact that this effect is obtained by small doses, and is not preceded by any indication of a preliminary stimulation unless the drug is given in sufficient concentration to cause a temporary reflex effect.

EFFECT ON HEART AND BLOOD-VESSELS.

The action of alcohol on the circulation after its absorption into the blood has been carefully worked out by experiments upon animals. The results are not entirely in accord, but the conclusion we are forced to come to is that there is no proof from these experiments that alcohol present in the blood in any concentration compatible with the amount given and with the symptoms exhibited has any action on the heart or blood pressure sufficiently marked to be of importance in therapeutics. The presence of alcohol in the blood to an extent of 0.1 per cent. causes definite symptoms of intoxication, and when given in therapeutic doses where such symptoms are never produced the quantity in the blood must be less than this amount.

While evidence of stimulation is absent, one result of perfusion experiments upon the isolated heart by Loeb,[3] Dixon,[4] and Hamill[5] is worthy of notice—viz., that in an exhausted or feebly-beating heart the addition of small quantities of alcohol to the perfusing fluid causes an improvement in the beat, and at the same time some of the alcohol was removed from the perfusing fluid, having apparently been utilised by the heart muscle as a source of nourishment. The improvement in the circulation clinically observed in cases of exhausting disease is probably due to a similar action, combined with a sedative action on the nerve centres which regulate the action of the heart, and also a diminution of pain and anxiety.

The effect upon the pulse-rate in healthy men appears to vary with the individual, and when the disturbing influences of movements and excitement are avoided, as in the experiments of Higgins,[6] an increase of 1 to 4 beats per minute was found in 45 per cent. of the experiments, and in 55 per cent. no acceleration occurred.

The most marked effect of alcohol upon the blood-vessels is seen in the skin. The flushing is due to a paralysis of the muscular fibres in the walls of the small vessels which results in the capillaries being distended with blood; when frequently repeated a permanent enlargement of these vessels ensues. The increased amount of blood in the skin may relieve a possibly dangerous congestion in certain cases, and also promotes perspiration. Most important, however, is the effect of this dilation of the superficial vessels upon the temperature of the body. Alcohol is a cooling agent; the large amount of warm blood in the skin rapidly loses heat. The increased heat production due to the oxidation of the alcohol in the body is quite inadequate to compensate for this loss of heat. When it is desired to increase directly the heat loss from the body and at the same time relieve congestion of internal organs and calm the nervous system alcohol may be used as an antipyretic drug; but the danger, now so well known, of the use of alcohol before exposure to cold must never be lost sight of.

OTHER EFFECTS.

Apart from its reflex effects alcohol has singularly little action upon respiration; this question, after the careful work of Higgins,[6] may be considered settled. The same may be said of its action upon the kidneys. This, of course, does not imply that large quantities of

*Part of a paper read before the Society for the Study of Inebriety. From a report in *The Lancet*.

[1] Harrington: Boston Med. and Surg. Journal, 1903.

[2] Clive Brooks, Journal Americ. Med. Assoc., July 30th, 1910.

[3] Loeb: Arch für exp. Path. and Pharm., 1895, lii., 459.

[4] Dixon: Journal of Physiol., 1907, xxxv., 346.

[5] Hamill: Ibid., 1910, xxxix., 474.

[6] Higgins: Journal of Pharm. and Exper. Therap., 1917, ix., 441.

alcohol, or alcoholic beverages containing other constituents, have no action on the respiration and kidneys; indeed, the contrary is the case, but this action has no bearing upon the use of alcohol as a drug. Upon the action, if any, of alcohol upon those small but important structures, the endocrine glands, we know nothing.

As to the influence of alcohol upon the various infectious diseases, the possible concentration of alcohol in the blood, even in a state of intoxication, rarely exceeds 0.25 per cent., and 0.6 per cent. is usually fatal. This concentration is quite insufficient to have any antiseptic action upon pathogenic organisms. Alcoholic subjects with degenerated tissues are well known to fall easy victims to infectious diseases, and there is considerable evidence that even in non-alcoholic subjects a dose of alcohol will lower the resisting power to infection by the pneumococcus, *Streptococcus erysipelatosus*, *Staphylococcus pyogenes*, and probably *Diplococcus rheumaticus*.[20] [21] There is some evidence that alcohol has some power to neutralise the toxins produced by the *Bacillus typhosus*, the *Bacillus coli*,[7] and the tubercle bacillus.[8] [9] Much further work is required on this interesting and important subject.

The alcohol circulating in the blood is gradually burnt up in the body, and by its combustion it supplies heat and energy; as the rate of oxidation is comparatively slow it serves the purpose of a food for some considerable time, but with therapeutic doses 95 per cent. is burnt up in 24 hours and only 5 per cent. excreted. The amount which can thus be utilised is strictly limited, and an increase in the amount taken does not lead to a more rapid oxidation; for example, Higgins found that 45 c.cm. is not burned at a faster rate than 30 c.cm.—the former required 12 and the latter 8 hours.

The careful experiments of Neumann[22] have shown that alcohol up to 100 g. daily can replace a chemically equivalent amount of fat in the dietary. 1 g. of alcohol gives 7 calories, compared with fat 9.3 and sugar 4.1. As much as 40 per cent. of the carbohydrate needs of the body can be supplied by alcohol, and a still larger proportion in the case of a patient confined to bed.

The value of alcohol as a food must be discounted by its concomitant actions as a drug. There is no doubt that it is not a necessary food in health; whether it is a desirable food is largely a matter of opinion, but there can be no doubt that there are conditions of disease where its sedative action on the nervous system may be desired and where the digestive functions are in abeyance. Here a form of hydrocarbon of high calorific value, which requires no digestion, is quickly absorbed, and readily oxidised may be of very considerable value, and on this account alcohol may be preferred in such cases to other narcotics of greater potency, but which lack any nutritive properties.

THERAPEUTIC CONSIDERATIONS.

I have now enumerated all the actions of alcohol which can be utilised in the practice of medicine; and powerful as these actions are I want to lay stress upon the fact that we have no proof of any direct stimulating action of pure ethyl alcohol upon the functions of the body after absorption. A substance which possesses such powerful actions may be approved or disapproved, but cannot be ignored as a drug, and our knowledge of the true place of alcohol in therapeutics would soon be largely increased if it were always prescribed with a definite aim and an exact idea as to what it was expected to do in any particular case, and not in that vague indefinite way in which it is sometimes the custom to order so-called stimulants.

For therapeutic purposes I should place the dose at the equivalent of from 20 to 180 c.cm. of pure ethyl alcohol in the 24 hours, and I doubt whether any further benefit can be obtained by more than the latter amount, even in subjects already habituated to alcohol.

The alcohol can often be prescribed with advantage as 50 per cent. alcohol (proof spirit) made up like any other powerful drug in a mixture with such disguising agents as tinct. gent. co., tinct. card. co., tinct. cinchon. co., or spir. chloroformi.

So far I have considered only the effects of pure ethyl alcohol, and I hesitate to enter upon the difficult and debatable ground of the actions of the various alcoholic beverages as compared with pure alcohol; for some purposes they may be better and for others worse owing to the presence of other constituents, but exact knowledge on these points is still lacking. These other constituents include a number of volatile substances, some the higher alcohols, and others the so-called ethers, of the constitution and action of which we know little; wines and beers contain in addition sugars, gums, organic acids and their salts, tannins, bitters, and coloring substances. How far and in what manner these substances modify the action of ethyl alcohol requires investigation.

In experiments upon animals the action of the potable spirits is essentially that of ethyl alcohol and proportional to their alcoholic content, therefore any difference observed in their action on man must be due to an action upon those brain centres which are not developed in the animals used for experiment. Part at any rate of the difference not infrequently noticed between the effects of different alcoholic beverages may be due to the specific stimulation of olfactory nerve-endings. We all know how extraordinarily powerful an odor is in reviving old memories and starting trains of association in our consciousness. Possibly some of the differences noticed in the relative effects of different alcoholic beverages may be due to the effects of the volatile odoriferous constituents arousing different trains of association.

I am of the opinion that it would be of advantage to the community if all distilled spirits were looked upon and used as drugs only.

[7] Hare: Therap. Gazette, May, 1903.
[8] Mercola and Gervino; Gaz. deg. Osped., No. 44, 1903.
[9] Ranhome, A.: The Treatment of Phthisis, 1897.
[20] Laitinen: Zeitschr. f. Hyg. u. Infect. Krank., 1900, xxxiv., 206, et seq.
[21] Parkinson: *The Lancet*, Nov. 27th, 1909, p. 1580.
[22] Neumann: Arch. f. Hygiene, 1899, xxxvi., et seq.

The Story of a Grass*

GRASSES form one of the largest and most widespread families, adapted to very different conditions of soil and climate, but with a remarkably uniform plan of structure. Wherever conditions allow of plant-life on land, there, almost without exception, the family is represented. In number of species the grass family falls short of other great families of flowering plants, Compositæ, Leguminosæ, or Orchids, but in the aggregation of many individuals of one and the same or a few species, either growing alone or densely scattered through a mixed herbage covering large areas, it forms a pre-eminent type of the earth's vegetation—as, for instance, in the grass-carpets forming the meadows or pastures of temperate or cold climates, or the coarser growth prevalent over vast areas, as in steppe or prairie vegetation.

These sociable grasses play an important part in the general scheme of plant-life; they protect the soil from too great evaporation of water, and cover up other plants in the resting stage, such as bulbs, tubers, etc., during the cold or dry season. The penetrating effect of the roots and underground stems helps to break up a stiff soil and fit it for other plants. Examples of the great variety of habitat in which grasses thrive are seen in the short turf which covers limestone areas, where the soil is too dry and thin to support trees or shrubs; in the luxuriant growth of meadowland where it thrives together with a variety of other herbs; in the reed-grasses which are associated with water; in the coastal mud-flats in Hampshire and Sussex, which are being rapidly reclaimed by the growth of *Spartina Townsendi*, a vigorous-growing hybrid which has spread over large areas during recent years; or the sand-dune grasses, which bind and fix the sand dunes and prepare the way for a more varied and permanent type of vegetation.

The adaptation necessary to accommodate the plant to widely differing conditions of life does not involve changes in general plan of structure; for instance, in hot, dry, or exposed areas, where excessive loss of water by the plant must be avoided, this is effected by narrowing the leaf-surface, or rolling it over from margin to margin to protect the upper face on which are the water-transpiring stomata. The structure of the stem, a slender, hollow cylinder, strengthened by a band of supporting fibres beneath the outer layer, or strips accompanying the water-conducting tissue, gives sufficient strength, with the greatest economy of material, for the purpose required, namely, to carry up into the light and air the leaves, flowers, and fruits for the short period of active life, and to allow of the swaying motion which favors the processes of nutrition, of transfer of pollen, and of distribution of the mature fruits.

The mode of development of the branches at the base of the stem determines the habit; a tufted growth results from the upward growth of the buds in the interior of the leaf-sheath, as seen, for instance, in the "tillering" of cereals; while the turf- or sod-formation is due to the penetration of the sheath-base by the young shoot and its lateral development in the soil. Branching from the upper part of the stem is rare in grasses of the temperate zone, but occurs in tropical genera, and is characteristic of the bamboos, in which the woody stem often attains tree-like proportions.

Points of interest in the structure of the grasses are the mode of growth in length of the stem by a zone of growth above the place of insertion of each leaf, the rigidity of the stem at this tender-growing zone being maintained by the stiff, encircling leaf-sheath; the swollen "node" round the base of each leaf-sheath, which is able by a geotropic growth response to an alteration in its position to raise again to a vertical position a stem which has been laid; and the short prolongation of the leaf-sheath above the line of its union with the leaf-blade to form the membranous "ligule" which protects the entrance to the tube formed by the sheath.

The grass-flower and the association of flowers to form the inflorescence are very characteristic. The unit is the spikelet which contains one to several, sometimes many flowers. The character of the spikelet is determined by the bracts or glumes, the green membranous or papery scale-leaves which enclose the single flower and overlap each other in a double row when several flowers are present in a spikelet. The bract-leaf is a general method of protecting the flower-bud; in the iris, for example, each flower-bud is enveloped by a pair of bracts—the outer, farther from the main stalk, green and leaf-like, the inner, between the bud and the main stalk, thin and hyaline with a double keel on the back. In the iris the bracts wither as the flower opens, in the grass the bracts remain as the character-giving feature during flowering and fruiting, the flower itself being reduced to those organs which are directly concerned in the setting of the fruit. The pollen is distributed by means of air-currents, and the petals are represented merely by a pair of minute fleshy scales (lodicules) at the base of the flower, which, by absorbing water, swell and cause the bracts to separate, and thus allow the thread-like stamens to grow out and expose the delicately hung anthers from which the light dusty pollen is scattered by the wind; the feathery stigmas protrude later to catch the pollen-grains. In the great majority of grasses there are three stamens, as in the Iris family, and a single ovary bearing a pair of long, feathery stigmas and containing a single egg. The remarkable variety in the form of the spikelet and the inflorescence is achieved by variety in the form, size, and number of the glumes which constitute the spikelet and the degree of branching of the inflorescence. The color of the inflorescence is due to the color of the pendulous anthers, and disappears when these drop after shedding the pollen. Fertilisation of the ovule succeeds pollination of the stigma, and the ovule becomes the seed, which, except in a few genera, is permanently enclosed in and inseparable from the fruit. The fruit also generally remains enclosed in one or more of the glumes, which fall with it and by their light, papery consistency help in its distribution by wind. Frequently the outer glume bears a stiff awn on the back or tip, which is an effective aid to distribution, as it will cling to the coat or plumage of an animal or bird. In the steppe grasses of the genus Stipa the awn is sometimes very long and feathered, forming an admirable device for distribution by wind. The stiff awn is frequently spirally coiled in its lower portion and hygroscopic, and its coiling or uncoiling with the varying degree of moisture in the atmosphere is arranged so as to drive the pointed end of the glume, in which the fruit is enclosed, into the ground.

The seed contains the embryo at the lower part of one side; the rest consists of a food store of starch and gluten to nourish the embryo on germination. The embryo has a well-developed stem-bud or plumule and root; the plumule is enveloped by a sheath (coleoptile), which appears above ground in germination as the slender pointed green seed-leaf from which the true leaves successively break. The food store in the seed is rendered soluble and absorbed by a flat sucker (scutellum), which is attached to the base of the coleoptile, and together with it represents the single cotyledon characteristic of the division of flowering plants, Monocotyledons, to which the grass family belongs.

*Abstract of a discourse delivered at the Royal Institution by Dr. A. B. Rendle, F. R. S. Republished from *Nature*.

New Stellar Photometer

LIGHT from an artificial source is reflected from a small silvered portion of a glass plate inserted at 45 degrees in the path of the rays from an object-glass to the eyepiece. The focus is adjusted so as to give an out-of-focus image, in the center of which will be seen the illuminated silver disc. Adjustments are then made so that the artificial light is just invisible on the starlight. Difficulties owing to differences of color of starlight and artificial comparison are remedied by interposing colored screens.—Note in Sci. Absts. on article by M. MAGGINI in *Compt. R nd.*

Courtesy University Museum, Philadelphia

Making fire by the drill method; first operation

Courtesy University Museum, Philadelphia

Making fire by the drill method; second operation

The Macoa Indians of Venezuela—II

Expedition Among a Little Known but Ancient Race

By Theodoor De Booy

[Continued from Scientific American Supplement No 2244, January 4, 1919, Page 10]

The interior mountains of the Perijà range are always covered with a dense fog from about two in the afternoon until the following morning, when at ten o'clock the sun appears to have sufficient force to dispel the clouds. As a result, even though the altitude of the Macoa camp was but 3,600 feet, and the equator only ten degrees distant, the climate was disagreeably cold, and I was forced to sleep under two heavy blankets at night. In the evenings and early mornings a campfire felt especially grateful. The clothing of the Macoas also was a direct response to the cold climate. Unlike the other tribes of the northern regions of South America, the Motilone is heavily dressed. The male apparel consists of a cotton robe, shaped like an enormous sack, with a slit for the head and two apertures for the arms. It is woven out of one piece of goods which is doubled over and sewed along the sides until some short distance from the top where the openings are left for the arms. The robe is exceptionally heavy, and serves as a dress and blanket. The women wear a loincloth and cloak, also made of cotton that weighs more than heavy canvas. About the middle of the day it is not unusual for the women to divest themselves of the cloak and use the loincloth only. Macoa children are dressed in miniature editions of the robes worn by their parents, only the youngest infants going about naked.

The Macoa makes use of seeds found in the mountains for his ornaments. Strings of these are worn, sometimes as necklaces and sometimes as bandoliers. The women wear the same strings that are worn by the men, and also occasionally use a head ornament consisting of a string of seeds which rests upon the crown of the head. The strings are sometimes embellished with gaudily-colored toucan feathers and with the teeth of small animals. Black, red-and-black, scarlet and gray seeds are used for these ornaments, and are sometimes very handsomely arranged. Glass beads are of course unknown to these Indians, and I found that the trade-beads I had carried with me were objects of great admiration and duly prized by their recipients. In addition to these ornaments the men wore woven head dresses of an unusual type. These consisted of a woven strip of cotton goods, cream-colored with a brown stripe, which was placed on top of the head and hung down the shoulders of the wearer. The more important men of the tribe wore this strip decorated with pendant strings of about four black seeds and one large red seed. These headcoverings can serve of no other purpose than that of ornamentation; they do not protect the head against rain or sun, nor do they give any warmth. It is my belief that these strips represent a conventionalized carrying-band such as is attached to baskets and loads that are transported upon the backs of the Indians. There were also two straw hats among the Macoas of a most unusual conical shape with a very narrow brim, the crown being encircled with a bunch of small toucan feathers of brilliant hue. I was informed by the Tucucu interpreters that these hats were formerly worn by all male Indians, but that since the last migration of the tribe the straw from which the hats were made was unobtainable, and that in consequence no more hats were being made. It is quite likely that, unless the Macoas return within a short time to the region where the straw is found, the art of making these headcoverings will be lost. The Indians also told me that it was customary, in former days, to cover the crown of the hat with one of the woven headdresses, of which the pendant streamers would fall on the back of the wearer.

Photographs by the author.

Courtesy University Museum, Philadelphia

Male Macoa in full dress

All Macoas go in for face-painting, three colors being used, viz.: black, brown and scarlet. The black designs are made with an application of crushed charcoal, while the brown paint is derived from the pulp of a tree. The scarlet paint is very sticky and far more durable. This is manufactured from the crushed seeds of a certain bush. Even the smallest infants are painted, and men and women alike appear to take pleasure in ornamenting their faces with intricate designs. Sometimes a Macoa will paint his face an even black or scarlet, while at other times he applies a design consisting of brown stripes and black dots. Again, he will appear with a face that is ornamented with black cross-hatchings. These Indians use all sorts of stamps and stencils for the applying of the paints or powders. The different pigments are kept in very small gourds that are carried on the longer hunting trips and travels of the Macoas. The applied designs are allowed to wear off—the Macoas never wash—before a new application is put on.

Like the majority of the warfaring South America tribes, the Macoas had one special design which they applied to their faces only when going on the warpath against a neighboring village. This particular design they would however not paint on their faces unless they were actually going to fight, and despite my entreaties I could persuade no single member of the tribe to act as a model for its application. According to the ideas of these Indians, anyone who painted his face for war and then did not go forth to meet his enemies, would be pursued by ill-luck for the balance of his life. Finally I asked a Macoa if he would paint the design on my face, as I was, for ethnological reasons, extremely anxious to know the exact pattern. To this no objection was made, the Indians evidently not caring how much bad luck might follow me subsequently. Amid the greatest interest of the assembled Macoas I consequently donned a new robe which the Indians had woven for me, and borrowed the necessary necklaces, bandoliers and weapons. After this a Macoa got out his gourd of black powder and placed a simple design consisting of squares and straight lines on my face. In this manner did I finally learn the fighting design of the Motilone Indians.

It was interesting to find these Indians still making use of the drill-method in order to make fire. Matches were, naturally, unknown to them, and although they were acquainted with flints and their use, they appeared to place more reliance in the surer method of drilling a hardwood reed upon a piece of softer wood. The hardwood reed was hollowed out in the bottom and some tinder placed in the aperture. The reed was then rested upon the soft stick and rapidly revolved between the hands which steadily moved downward. As soon as the hands were almost down to the end of the reed, another Indian would catch the stick at the top and continue the rotary motion, the first Indian in the meantime releasing his hold and getting ready to take up the operation again when the second Indian had come near the end. In this manner the

Photos by courtesy of University Museum, Philadelphia

Macoa men dancing at a chicha feast

Small intoxicated boy and men at a chicha feast

produced friction finally ignited the tinder in the aperture of the hollow reed. By blowing through an opening which had previously been made in the side of the stick, the tinder burst into flame, and was then rapidly transferred to some wood shavings upon which the materials for a fire had been laid.

The Macoas differ, in many ways, from the aborigines inhabiting other parts of South America. In the first place, they sleep upon woven grass mats, instead of in hammocks. They are, however, acquainted with hammocks, as these are used for new-born infants who are put to sleep on a small woven mat which rests in a hammock-cradle made of cords in the same manner as a fishnet. In this connection it was interesting to note that the infants laid crossways in the hammocks and not lengthways. But the larger children and all adults sleep on the ground, on mats about five feet long and two feet wide which are made of straws that have been fastened together by means of interlaced cords.

Another point of difference between the Macoas and other tribes from northern South America is that the men of the former tribe are hard workers and good agriculturists. The women take no part in this work, whereas it is usual for other aboriginal races to leave agriculture exclusively to the women. Again, the men are expert basket weavers, and yet do not weave cotton; the reverse is generally true among the other Indians. The soil of the Macoa regions is intensely fertile, and the excessive moisture in the mountains a great aid to agriculture. As a result, the produce patches of the Macoas are filled with bananas, yucca, yams, sweet potatoes and corn, and the Indians secure large crops with almost no labor.

The Macoas differ also from other tribes in that the men are expert basket weavers, an operation which is generally carried out by the women in other parts. On the other hand, the Macoa women do all the textile weaving, and this in most other tribes is done by the men. Other points in which the Macoas differ is that their musical instruments do not resemble those from other regions and that their manner of preparing "chicha," an intoxicating drink in common use by the natives of South America, differs from all other methods.

Taking him all in all, I found the Macoa extremely obliging, glad to serve the "white stranger" in all ways, and only too happy to donate specimens of his manufacture and to accompany me on the trips I undertook to explore in the interior of the Sierra de Perijà. It was only when drunk on "chicha" that he became quarrelsome and dangerous, but in this the Macoa resembles the human race in general. The Macoa has a well-developed sense of humor which is especially noticeable whenever a member of the tribe meets with an accident of some kind. Instead of sympathising with the sufferer the other Indians give vent to hilarious roars of laughter.

The Macoas are unacquainted with the blowgun and use bows and arrows exclusively for the chase and for warfare. They do not know the use of the spear either, but catch certain of the larger animals by means of ingeniously devised traps. These Indians are surprisingly adept in the use of their weapons, and can hit the smallest mark at an incredible distance. The boys are taught archery from their earliest infancy, so that it is no unusual sight to see a small tot practising with a bow about a foot long, and arrows that are even shorter. A favorite boys' game is the confronting of two teams with arrows that have been tipped with corncobs. They attempt to hit each other with these arrows, and the first team making the largest number of hits is acclaimed the winner. The iron points used on the fighting and hunting arrows are laboriously fashioned from pieces of hoop-iron that were acquired by the Tucucu Indians in exchange for their work in the lowlands; these points are in consequence highly prized owing to the difficulty in obtaining the material, and the subsequent large amount of work that was spent in rubbing them to the required shape. The Macoas are unacquainted with the use of poison on their arrowpoints, although it is claimed in Colombia, on the other side of the Sierra de Perijà, that the other Motilone tribes are in the habit of applying some poisonous substance to their weapons. I imagine however that this report may have found birth in the imagination of the Colombians, who are but too glad of an excuse to vindicate their custom of shooting a Motilone Indian on sight. The Macoas told me of a custom that was followed by the Pariri Indians to the south to protect themselves against sudden raids on their territories. My informants said that the Pariris were in the habit of making small pits in their trails in which they place a large thorn that had previously been dipped in some sort of vegetable poison. The pit was then carefully covered with twigs upon which mud was plastered, so that the trail resumed its normal aspect. Any barefooted Indian coming along would of necessity break through the covering of the pits and run the poisonous thorn in his foot.

One of the greatest dangers of the Macoa country was the presence of various species of highly poisonous snakes. These reptiles were a constant menace to the unwary. The Macoas however did not have the same fear of these animals that was experienced by me, as they claimed to have a sovereign and infallible remedy against poisonous bites. In this they resembled the inhabitants of the western slopes of the Sierra de Perijà who also claim to have a cure against snake bites. The first mention of this cure can be found in a work by the French geographer Reclus, who visited the Sierra Nevada de Santa Marta and the western slopes of the Perijà range, and who states that: "the *guao*, a well-known plant, of which the sap, inoculated in advance, certainly preserves from death all who have been bitten by poisonous snakes. The country people who desire immunity inoculate their thumbs with a small part of the cellular tissue of the leaves of the *guao* and drink an infusion made from the small branches; they repeat this inoculation every fifteen days for some months and can then brave the dangers of vipers and coral snakes with impunity. The *guao* is so named

Tucuca with large bow and arrow

Courtesy University Museum, Philadelphia

Macoa women grinding corn to make chicha

from a bird, commonly found in New Granada, which will, according to reports, in its fights against snakes, perch itself on this plant and fortify itself by hastily eating some of its leaves.[1] While in the Macon country I was fortunate in seeing this cure applied in the case of a small infant that had been bitten in the neck by a scorpion. The mother of the child hastily chewed the seedpods of a plant named "kontrarèpa" by the Indians, and applied a poultice of this chewed matter against the bite. She furthermore prepared an infusion of the leaves and pods and made the child drink of this. I was considerably surprised to note that no swelling appeared on the child's neck subsequently, and that the infant appeared to suffer no ill effects from the bite. I imagine that the "kontrarèpa" must contain some alkaloid which is decidedly efficacious in treating poisonous bites. The Indians declared that the infusions and poultices would cure bites from the most poisonous varieties of snakes known to them. They were not familiar with the system described by Reclus of inoculating their thumbs, but did state that a certain bird, a constant and invariable enemy of the snakes of the region, is in the habit of eating of the leaves and seeds and thus protects itself against any bites it may suffer in encounters with the reptiles. I succeeded in obtaining some 500 well-dried seeds of this plant and an excellent photograph of the plant in flower. It is well possible that the "kontrarèpa" of the Macoas is the same as the *guao* of the neighboring Motilones.

During my stay with the Macoas a rather amusing occurrence took place which showed that after all, poisonous snakes may be of some use. Like all other Indian tribes the Macoas had quantities of dogs of all varieties, all belonging to the species "cur." The ancestors of these same quadrupeds had probably been collected during raids to the lowlands in the days when the Indians waged active warfare on the Venezuelans. The breed, in subsequent years, certainly had not improved. The dogs were a nuisance around my camp as they preferred my abode to that of their Indian owners owing to the fact that my food supplies were so much larger. One day a large and highly poisonous snake was killed some short distance from my hut. It was promptly buried in order to prevent the dogs from making a meal off the serpent. Nevertheless an enterprising dog dug the snake up after a day or two and literally gorged himself on the decaying meat. As soon as this was found out the owner of the dog wasted no words, but acted promptly, with the result that a dead dog was buried in another spot. The same thing happened again with this difference that instead of exhuming a snake, a second dog dug up his defunct brother and displayed his cannibalistic tendencies by eating heartily of the corpse. This dog also was elected to fill an unhonored grave on the hillside. By now I was much encouraged and had visions of successive killings of the Macoa dogs, but in this I was disappointed. Whether the second dog was too deeply buried to allow for exhumation by its fellows, or whether the death of the two previous dogs had a salutory effect upon the rest of the canines, I cannot state. Anyhow, no more dogs were offered upon the alter of their own gluttony.

I lived among the Macoa Indians for almost two months, and assisted at two of the "chicha" feasts that were held during my presence. The making of the chicha was not a very complicated operation. Sprouting corn was ground on a mealing stone and the crushed product packed in leaves and then soaked. This converted the starch of the corn into sugar. The balls of crushed corn were now placed in the sun to dry, after the enveloping leaves had been removed, and would then partially ferment. Finally the balls were placed in an immense wooden trough together with water, crushed sweet potatoes, crushed yams and crushed bananas. Active fermentation would immediately set in, and after twelve hours the "brew" was ready. In the meantime the Indians took special pains to paint their faces as handsomely as possible. Certain members of the tribe made weird and monotonous music on flutes that were dedicated to this service alone. About six in the evening the feast commenced.

It was a matter of etiquette among the Macoas not to break up the feast until the last drop of chicha in the woden troughs had been drunk. Luckily the second feast I attended did not finish until about eight in the morning, which gave me an opportunity to take pictures of the last stages of the celebration. These are perhaps the first pictures taken showing an absolutely savage race during a chicha feast.

When the feast commences the behavior of the Indians does not differ greatly from their usual manner. After about two hours' drinking they become very quarrelsome and generally collect their weapons which they have previously discarded. It is at this stage of the feast that fights are liable to commence. During the first feast attended two brothers attempted to kill their elder brother who was the chief of the tribe. The murder was only prevented by the intervention of some of the other Macoas. Another of the Indians, for some reason known only to himself, became enraged with his wife and struck her thrice with his heavy bow, using the sharp edge and producing three long gashes on the crown of her head.

During the second feast I obtained an insight in the unreliability of the Motilone character. At some time previous to the first chicha feast I had given medicine to the old chief who complained of heartburn and weak eyes. This medicine had been the means of making the old Indian feel considerably better and was, according to the other Indians, the direct cause of the quarrel between him and his two brothers at the first chicha feast. It seems that previous to the cure, the chief had been content to leave matters of government to his brothers, and had not interfered with the affairs of the tribe. After the cure he attempted to reassert some of his vanished authority and this provoked the quarrel. I had heard nothing of all this until the beginning of the second feast, when various drunken Indians became rather threatening and indicated that they considered me directly responsible for the previous trouble. While sober these ideas would not have been expressed, but while drunk it was a hard matter to convince them of my innocence.

About midnight the Indians were sufficiently drunk to arrive at the maudlin stage. They laid aside their weapons and gave themselves up to the pleasures of the flowing bowl (in this instance it might be better to say, to the pleasures of the flowing trough), and to those of a solemn and grotesque dance. Men, women and children alike were now drunk, and chicha was even given to infants of the tenderest age. Sometimes an Indian would stagger and fall down, but his friends would immediately pick him up and insist upon his continuing the dance. The chicha ran out at about six in the morning at the first feast, but the Indians had prepared such a large quantity of liquor for the second performance that the feast lasted some two hours longer. At the end of the feast, the clearing was strewn with drunken Indians who slept where they had fallen. Strange to say, the Macoas apparently felt no ill-effects after the chicha-feast was over, and the following day appeared to be as fresh as ever and ready to accompany me on any trip I wished to undertake.

[TO BE CONCLUDED.]

[1]Reclus, Elisèe. "Voyage à la Sierra Nevada de Saint Marthe." Paris, 1861, pp. 215-6.

The Theory of Fertilizers

THE amount of food that may be realized from any region depends upon two obvious factors—the area of soil and its fertility. In a new or pioneer country land is plentiful, and the need of an increasing food supply for a growing population is met at first by enlarging the area cultivated; but, sooner or later, there comes a time when further enlargement is impossible and food must be imported or else the yield of the soil must be increased by artificial means. The world has already reached the stage where in all regions of dense population the latter is imperative—a fact which should have the widest and most thorough appreciation.

Various means of increasing soil productivity are practiced, but the most important gain is attained by adding certain products directly to the soil. These substances are the so-called fertilizers. A glance at the nature of soils and the chemical reactions that take place in them to produce plant growth will make clear the part that fertilizers play in accomplishing their important function.

To begin with, soil does two things: It forms a mechanical medium for supporting and protecting the growing plant, and it supplies the plant with some of the chemical material to be built into its structure. The rest of its substance the plant obtains from the air, from moisture, and from the bacteria present in the soil, although the last may be regarded as part of the soil itself.

The chemical material contributed by the soil focuses our interest here—the calcium, the phosphorus, the sulphur, the nitrogen, the potassium, the sodium, the magnesium, the iron, and some others. These substances are not present in their elemental or simple condition, but as compounds available for transfer into the body of plants.

These elements are likewise present in the solid rocks that everywhere underlie the soil, but in combinations wholly unfitted for sustaining plant growth. They must first be rendered suitable by the general process of natural rock decay called weathering, which mechanically reduces the solid rocks to the consistency of soil and chemically prepares their components for the sustenance of life. The soil then becomes the laboratory in which the gases of the atmosphere, with water, and certain constituents of decayed rock are combined into the organic products, or plants, upon which human life ultimately depends.

In the normal course of events, plants spring up, live their course, and die, giving back to the atmosphere and soil the elements employed in their life cycle. Thus it is that the rank growth of the jungle is unremitting. But where plants are removed by artificial means, the balance is upset and the soil is depleted in respect of some of its essential compounds. But soil is not static; the processes of weathering are continuous, and if the plant removal be stopped for a sufficiently long period, the deficiency will be naturally remedied by the transformation of a further quantity of needed compounds into an available or soluble condition. This result, however, cannot be waited for; in populous sections the soil must be cultivated continuously; the elements removed too rapidly must be replaced artificially, that is, by the use of fertilizers. This is an absolute, basic necessity. Fertilizers, indeed, play a more fundamental part than that of merely increasing yields and profits; no soil can be cultivated continuously without their use.

Fertilizers, moreover, have an application beyond that of making possible continuous and intensive cultivation; by their use, many soils can be rendered fertile which are deficient in one or more essential constituents by virtue of peculiar geologic history. Thus fertilizers extend the possibilities of food production to great areas unfitted by nature for productive yield.

These considerations of the social value of fertilizers are aside from the economic advantage of their use as leading to greater profits to the acre and greater yields to the unit of labor expended. Yet this economic advantage is the great motive force which, under existing conditions at least, must be counted upon to carry fertilizer utilization to its proper realization.

By long experience, it has been found that those elements of which the soil is most quickly depleted are nitrogen, phosphorus, and potassium; and therefore compounds of these elements are the chief ingredients of the commercial fertilizers. Calcium, in the form of lime or crushed limestone, is added with favorable results to some soils; but this is more to counteract or neutralize a high acidity or "sourness" than to contribute a needed constituent, and since, moreover, limestone is so widely distributed that an organized industry is not necessary to supply it, this substance will not be considered in further detail in this paper. Sulphur, in the elemental condition, has recently come to the front as a fertilizing material of some promise, but its use, as well as that of sulphuric acid on the alkali lands of the West, may be said to be still in an experimental stage. The fertilizer industry, therefore, as it exists at present, is concerned with the preparation of suitable compounds of nitrogen, phosphorus, and potash to form commercial fertilizers, which are distributed for immediate addition to the soil. The securing of an adequate supply of raw materials, and the development of a wider and more intelligent use of fertilizers, are two problems of the utmost importance, especially at the present moment, when the World War endangers certain of the supplies and at the same time necessitates an increased yield in food.—*From U. S. Natl. Museum Bulletin*, No. 102, part 2.

Industrial Application of the Coloring Matter of the Glumes of the Sweet Sorghum

THE glumes of the sweet Sorghum and of several varieties of Sorghum with black glumes contain a dye, which can be extracted with dilute acid and which dyes wool, silk, leather and cotton. The dye is extracted by heating the glumes in an autoclave with 1 per cent sulphuric or hydrochloric acid or with 2 per cent sodium bisulphate. The colors obtained on wool and silk are bright and strong, the shades being from violet to red, from beige (natural wool color) to brown, and from pearl grey to deep grey varying with the mordant. The dye may be used with or without mordants, the most satisfactory mordant being stannous chloride, which gives bright amaranth and crimson tints. All the shades are fast to washing. They pass a little toward violet under the influence of alkali, the tint being restored by dilute acid.—*Note in J. Soc. Chem. Ind. on an article by A. Piedallu in Comptes Rend.*

Sewage Disposal by Dilution

ONE of the most interesting and valuable sections of the practical work carried out by the Royal Commission was its investigations into the self-purifying capacity of rivers and the conditions under which sewage could be discharged direct into rivers without being highly purified, generally known as "disposal by dilution"; and a large scheme has been constructed since the war began, in which these investigations have been utilized to apply the second recommendation mentioned above, with satisfactory results.

After the most suitable site for the disposal works had been selected it was found that the sewage effluent could be discharged into a brook about 400 yards from the works, but this would have necessitated a high degree of purification involving a large initial outlay for the construction of elaborate tanks and a large area of special filters and other accessories. By conveying the sewage effluent about 400 yards beyond the brook it was found possible to discharge it into a river of considerable volume with a rapid flow and fully saturated with dissolved oxygen. Having regard to the information contained in the Report of the Royal Commission, coupled with his own previous experience, the consulting engineer who was called upon to deal with the matter, recommended a scheme of disposal by dilution, which was eventually adopted.

There are two important factors in the success of a system of disposal by dilution. The first of these is the removal of the maximum amount of the solids in suspension in the sewage, because if these are discharged with the liquid they are deposited upon the bed and banks of the river and eventually accumulate to such an extent that the organic matter putrefies and creates a nuisance. The other factor is the prevention of putrefaction in the liquid sewage so that it may reach the river while still fresh. A sewage which has become septic or putrescent has such a great avidity for oxygen that if it were discharged in this state it would deprive the river water of the whole of its dissolved oxygen immediately and not only be liable to cause a nuisance, but certainly be injurious to fish life for some distance down the river. In the present case it was also desirable to make provision for the thorough digestion of the sludge, so that it could be easily dried and utilized as a fertilizer on the land.

To secure these three results, *i. e.*, the maximum removal of solids in suspension, the production of a fresh effluent, and the thorough digestion of the sludge, it became necessary to design a special type of settling tank. Fortunately, owing to the local conditions of fall, it was possible to construct the sewers with such good gradients that the sewage reaches the works in a fresh state without putrefaction having been set up while in the sewers.

On its arrival at the works the sewage first passes through screens which arrest such matters as rags, tins, pieces of wood, and cardboard, which are removed by means of hand rakes. It then flows through detritus tanks where the mineral matter such as grit and stones is deposited. After leaving the detritus tanks it passes into the special settling tanks, four in number, and each divided into three compartments. Each first compartment has four submerged inlets, and the outlet is in the form of a weir along the full width of the tank. In these first compartments the bulk of the grosser solids are arrested and provision is made for emptying them completely at frequent intervals, as described later.

The second compartment receives the effluent from the first for the further settlement of the finely divided suspended matters remaining in the sewage, which then passes out over a long weir to the effluent channel constructed between the second and third compartments. The combined capacity of the first and second compartments of the four tanks, was arranged to be equal to about three to four hours' flow of the estimated volume of sewage, this period being sufficient for the settlement of a high percentage of the suspended solids, but too short to permit putrefaction. By this means the two important requirements previously mentioned were satisfied.

The third compartment is a deep tank, connected to and forming practically one tank with the second compartment, but arranged in such a manner that the sewage flows through the latter alone. Arrangements were made whereby the whole contents of the first compartment can be discharged into the third, and this is done weekly. In this way the liquid capacity of the first compartment is maintained and the whole of the sludge (including scum) is delivered into the deep third compartment, where it is retained for three to four weeks to undergo thorough digestion. The sludge is never entirely drawn off from the deep compartment; only the lower thoroughly digested layer at the bottom is discharged at intervals of three to four weeks upon special sludge draining beds, where its moisture content is reduced from about 92 per cent. to 72 per cent. in from eight to ten days under average weather conditions. It is then in a "spadeable" condition, and is removed from the draining beds and taken in small tip-wagons on a light railway to the fields of the adjacent farm, and spread on the land. The beneficial effect of this sludge as a manure is evident from the appearance of this year's crops, and the main object from the sewage disposal point of view—*i. e.*, the disposal of the sludge—has been attained, as after 2½ years of operation, there is no accumulation of sludge.

From the following description it might be anticipated that even if the sewage, after leaving the tanks is still fresh there might be a local nuisance from the deep tanks in which the sludge is accumulated for digestion in stagnant sewage. This is, however, not the case. There is a remarkable absence of objectionable odors from this source. Scum is not formed in these tanks, and very little gas is given off. When the stagnant sewage is lowered in connexion with the discharge of the digested sludge a large amount of gas is liberated in bubbles at the surface; but it has no objectionable smell, and there is no trace of the septic sewage odor which is always noticeable in the vicinity of ordinary septic or sedimentation tanks. Further, even the discharge of the well-digested sludge upon the draining-beds does not cause a nuisance.

A novel feature of these works is the addition of a chlorinating plant for destroying the pathogenic germs in the sewage effluent. The sterilizing agent employed is a solution of chloride of lime, which is prepared in a special mixing plant operated by a water-wheel driven by the flow of sewage. The crude solution is allowed to settle in a tank, and the discharge of the clear supernatant liquid into the sewage effluent is regulated to vary with the flow of sewage by a special apparatus governed by the rise and fall of the sewage over a fixed weir. This weir is also used to operate a measuring apparatus by means of which daily records of the volume of sewage are obtained.

The sewage effluent after chlorination flows direct into the river. To ensure thorough mixing with the river water, the outlet pipe is arranged to discharge in the middle and at the bottom of the river at a point where there is a good volume of water at all times. Before noting the effect of the sewage effluent upon the river water it should be observed that although the water is fully saturated with dissolved oxygen it contains evidence of previous pollution by sewage in the higher reaches as indicated by the presence of *bacillus coli* in considerable numbers.

In order to fulfil the conditions, prescribed by the Royal Commission in connection with the recommendation already quoted, it is necessary to show that the sewage has not been the cause of actual nuisance arising from its discharge. There are several kinds of nuisance which may be caused by the presence of sewage in a river, such as objectionable odors, an increased degree of pollution as indicated by the presence of a larger number of *bacillus coli*, injury to fish life caused by the reduction of the dissolved oxygen content of the water below 50 per cent. saturation, and the formation of deposits of organic matter on the bed and banks of the river.

Several inspections of the river and analyses of the water have been made, and the results demonstrate that these conditions have been fulfilled. With the normal volume of water—*i. e.*, when it was not less than 40 times the volume of the sewage, the *bacillus coli* content of the river water was no greater below the outfall than above it, the dissolved oxygen was not reduced below saturation, and there was no objectionable smell or deposit of organic matter on the bed or banks. At very low water, when the ratio of dilution was as low as 18 to 1, which happens for a few weeks only in each year, the effect of the discharge of the sewage was more marked. At a point some 300 yards below the outfall the *bacillus coli* figures were greater than above the outfall, and the dissolved oxygen was reduced by just over 40 per cent. There still remained, however, sufficient oxygen to support fish life, and there was no nuisance from smell or deposit of sludge on the bed or banks of the river. This increase of the *bacillus coli* and reduction of the dissolved oxygen was a purely local effect, as an examination of the water about 1½ miles below the outfall showed that at this point the figures for both were again the same as above the outfall.

It is thus clear that, under certain conditions as to the volume and quality of the water, sewage may be discharged into rivers without creating a nuisance so long as it is subjected to suitable preliminary treatment. Some idea of the economy that may be secured by a scheme of this kind in places where the local conditions are suitable may be gathered from the fact that, by the omission of the filters and other additional works required for a high degree of purification, a saving of about £20,000 was effected in the case here described.—*London Times Engineering Supplement.*

The German Dye Industry

THE attention of manufacturers in the chemical and dye industries ought to be drawn to recent issues of the German trade papers, wherein the present position of the dye industries in various countries is reviewed in the confident fashion characteristic of the Teuton.

In the first place, they assert that British, French, and Italian manufacturers will be obliged to offer their dyes at high prices, whereas they, with the State-fed companies, can sell at cost price, or even less. Moreover, the Germans are prepared to offer other products of chemical industry on the same terms, by which they hope to undersell all competitors. There is certainly danger that they will make good their boast, because their factories and works have been organised on this basis for a long time.

The person most interested in the dye-stuff problem is probably the textile manufacturer, and it is in this industry that the Germans hope to introduce the entering wedge by means of new dyes which they have made by what appear to be new methods. In the chemistry of dyes there is always the possibility that among the new products there may be some of especial value.

Costly Intermediates.—At first many textile manufacturers placed considerable confidence in optimistic reports in the newspapers, and were lulled into a sense of security in the belief that all dye-stuffs used in Entente industry would be manufactured in England and America by processes much in advance of the antiquated German methods. Some of these experiments have been tried, such, for instance, as the extraction of a red dye-stuff from the cranberry, the belief being apparently that vegetable coloring matters might in some cases take the place of synthetic dyes. The result of this and other expedients showed that in the present critical time it is a mistake to endeavor to prepare dye-stuffs by new and untried methods. The making of the finished and useful dyes is not, in the judgment of chemists, a difficult and complicated problem provided the proper so-called intermediate materials are available. The crux of the problem lies in the economical production of these intermediates, the by-products of the gas and coke-oven tars. But all these products are at very abnormal prices owing to the demand for high explosives. There is a disagreeable modicum of truth in the German contention that these prices must come down before the dye industry of the Allies can be organised on a good working basis.

Strength of German Industry.—Chemists do not deceive themselves as to the astonishing amount of strength in the German dye industry. After the war Germany will mainly rely upon dye-stuffs as articles of commerce destined to recover a place in the world's markets and to compensate her trade losses in other directions. The chief factor in this strength is the simple truth that German factories can turn out dyes and other chemicals cheaper than any other concerns. The cost of making these products in other countries, notably England, was clearly brought out in trade journals, which quote the preparations made by the different Governments to meet the expense. In England, for example, it seems necessary to feed the industry out of State money. The sum required, according to Sir Watson Rutherford, is £40,000,000. This is regarded by business men of all lines as a heavy capitalisation to produce the two and a quarter millions of dye-stuffs imported prior to the war.—*Manufacturer, in Sunday Times, London.*

Asphodel as a Source of Alcohol

ASPHODELUS *ramosus*, which contains much starch in its tubers, grows as a common weed (porrazzo) in many parts of Italy; in fact, it has been called "the plague of the Mediterranean." At one time it was cultivated as a source of industrial spirit, but, owing to difficulties in the rectification, the culture was abandoned. If these difficulties could be overcome Italy would be able to considerably increase her home supply of spirit, for it is claimed that every acre of asphodel plants yields 17,850 lb. of roots from which not less than 107 gallons of alcohol could be obtained. When the manufacture of porazzo was carried out in Algiers the residue from the distillation was used successfully in the production of paper, but it could also be used directly as a cattle food. —*Annal. d'Ingegn. e d'Archit.*

Curious Projectiles

Specimens of German and Austrian Ingenuity

Among the various military devices invented in Germany and Austria either before or after the fateful days of August, 1914, some of the most curious are novel types of projectiles, and Albert Gandolphe has made a study of these, deriving his information from German and Austrian periodicals as well as from the records of the French Patent Office. He gives the result of his investigations in a recent number of *"La Science et la Vie."*

In 1909, to go farther back, Carl Walter Gebauer of Berlin, in order to insure to Germany the monopoly of manufacture, created and patented in all countries a shell which contains besides ordinary shrapnel balls small ogive-cylindrical projectiles designed to be discharged toward the rear of the large projectile itself by means of a fuse and a special charge at a given moment. The object of this was to reach enemies protected behind the fortification, as shown in Fig. 2. The small projectiles are inclined to the rear so as to form an acute angle with the axis of the large projectile. At the instant when the latter touches the ground the small projectiles which it contains are discharged to the rear, or else the detonation of the special charge is regulated by a time fuse so that they will explode at a distance varying from 800 to 8,000 meters from the point of departure. For this purpose a graduated fuse disc is located on the point of the shell.

The range of the large shell itself is increased—by a well known effect of reaction—through the rearward discharge of the small bullets, and neither the regulation of its time of explosion nor the dispersion of the shrapnel balls it contains are affected. There is another advantage, moreover, in the fact that the envelope of the large shell bursts into a greater number of small fragments than that of an ordinary projectile (thus increasing the destructive effect), by reason of the numerous niches or sockets with which the envelope is bored to hold these small shells (Figs. 1 and 2) and which form so many lines of rupture.

Another German, Heinrich Brust, likewise patented at about the same time a projectile (Fig. 3) designed to be fired against batteries sheltered behind a steel mask, against which ordinary shrapnel has no effect, and which percussive shells do not destroy unless the shot strikes the target, which is rarely the case. The body of this shell is divided into two portions—one above the other; the lower part containing shrapnel balls, and the upper part within which are placed tubes, rifled on the interior, which act like actual small guns and each of which contains a percussive shell, and which are supported by movable discs below which is placed the explosive charge to fire them. This disc can be adjusted at will and upon its position with respect to the body of the projectile depends the degree of rapidity of the ignition of the charge. The ensemble of this curious engine of destruction thus presents the combined advantages of a time shell and a percussive shell.

When the said charge explodes after a time regulated in advance by means of the adjustable disc, and which corresponds to a distance of 50 meters before the arrival at the object aimed at, the fuse plug (having a very slight channel) which the projectile bears at its forward end escapes, thus liberating the small shells. The explosions of the latter are occasioned in their turn by a fuse composition which is regulated and ignited so that the explosions take place 2/10ths of a second after the penetration of the objective.

The explosive with which they are filled must have sufficient force to destroy the steel shields when the latter are struck. The explosion of the shrapnel is retarded so that these balls find the road prepared by the percussive shells, and can thus readily strike the gunners of the battery against whom this diabolical projectile is aimed.

Because of this intimate combination of the time shell against the crew and of the percussive shells to destroy obstacles the chance of striking the enemy is increased in ratio to the number of small percussive shells contained in the large projectile. The latter can be fired either from an ordinary rifled gun or by one having a smooth bore; in the latter case a helicoidal fin arranged around the outside of its envelope serves to give it a rotary motion. The spaces between these partitions are filled with sulphur, colophony or some similar substance to obtain more certain guiding in the gun; when the shot is fired the heat produced causes this material to melt. This apparatus comes from Metallwarenfabrik in Histenberg Fridolin Keller.

The German Company Mannesmannröehren Werke also manufacture a projectile for smooth bore guns.

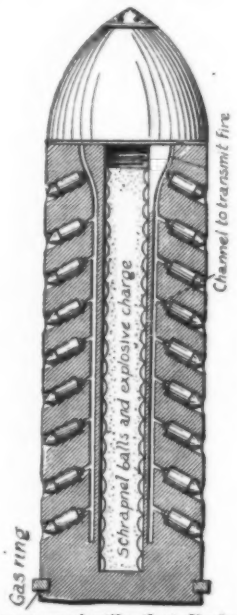

Fig. 1 Gebauer projectile that discharges small shells to the rear

It is provided with a central passage along its axis and carries in its rear end a small helical propeller wheel, which is fixed with reference to the body of the apparatus, which is in effect a cylinder open at each end. During its flight the air acts on this little propeller and imparts to the projectile a rotary motion suitable to cause it to operate normally (Fig. 4).

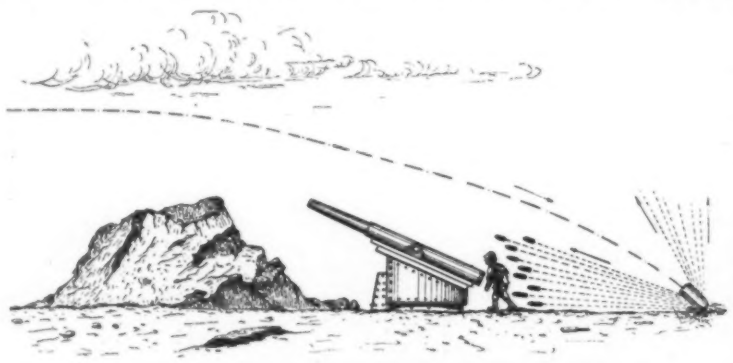

Fig. 2. Effect of the Gebauer projectile behind a masked gun

A false bottom or base plug, which falls off when the shell makes its exit from the gun, is provided to prevent the escape of the gases of the discharge through the aforesaid central passage. These gases, or the pressures produced in the gun, have but little injurious effect upon the bore because of the absence of rifflings, for it is chiefly these which wear rapidly in ordinary guns, and the gun therefore has a longer life.

Moreover the air pressure being less against the ogive or head of a projectile of this nature its trajectory, according to the constructor, will be flatter and its range as well as its power of penetration and destruction, greater. Furthermore an explosive can readily be placed within the thickness of the walls.

The *Deutsches Offizierblatt* of Berlin gives a description of a projectile carrying a bomb which is manufactured at Essen. The bombs or grenades thrown by hand and by mechanical means, or even by compressed air, have necessarily a very short range, and in order to increase this some method of fastening them to a projectile fired by a gun has long been sought; but inventors have met with an obstacle in the rotation of the said projectile which necessarily involves that of the bomb to which it is fastened. But since the weight and the volume of the bomb are considerably greater than those of the projectile, and since its diameter is too great for it to be introduced into the gun, this rotation is imperfect and rapidly slows down, soon becoming almost nil. It follows that the transit through the air is effected under particularly bad conditions; the projectile soon begins to turn somersaults along its trajectory, and since it ceases to progress point first the range is diminished to an undesirable degree, and the precision is almost entirely lost.

But the system described by the German review quoted above is said to be capable of throwing the bomb to any distance required in practice, in other words to about half the distance of projectiles shot by guns; furthermore the trajectory can be calculated and the target hit without depending on mere chance; these claims are said to be supported by tests on the Meppen range.

This result is obtained by means of a special system of operation of two devices which permits one of them to assume a rotary motion without the other taking part in this motion (Fig. 5). The rear portion of the bomb contains one opening capable of receiving the extremity of a shaft or rod connecting it with the projectile (this rod being of the same length as the bore of the gun, the bomb, which is of large diameter, being placed in front of the muzzle of the latter) and also comprising ball-bearings. This extremity of the shaft is contracted and threaded to receive a nut which holds it in place in the bearings, which are firmly fastened to the wall of the opening of the bomb, but offers no obstacle to its movement of rotation within these bearings. This movement is communicated to it when the shot is fired by reason of the rifflings of the gun, and because of the rifling bands which it bears like ordinary projectiles; but because of the method by which its extremity is inserted within the ball bearings, of which we have just spoken, it revolves within these as if they formed a solid block with the bomb of which they are a portion. It is this inertia in fact which prevents the latter from participating in this movement of rotation in spite of its being thrown forward by the projectile and the aforesaid rod of connection upon the ignition of the charge contained in the socket.

For this reason the ensemble in the projectile of the rod of connection and of the bomb can be regulated according to the laws of ballistics. Furthermore, thanks to this rotation of one portion of this ensemble, the bomb strikes the target with its point which is traveling in front, as it ought to do, instead of falling flat, which nearly always happens when it is thrown by hand or by mechanical means.

The Austrians likewise have constructed projectiles quite as original in form as the preceding; for example, the Acetylene shell of Heinrich Schreib, described and illustrated in *Danzer's Armee Zeitung*, of Vienna, and which is constructed in the workshops of G. Roth Aktiengesellschaft. It is a well known fact that acetylene gas is one of the most powerful explosives known, especially when highly compressed, and that it produces explosive effects comparable to those made by chlorated powder and almost rivaling potassium picrate and fulminiate of mercury. Therefore it can take the place in projectiles of the ordinary explosive charges whose transport and handling are the more dangerous and the more subject to accident the greater

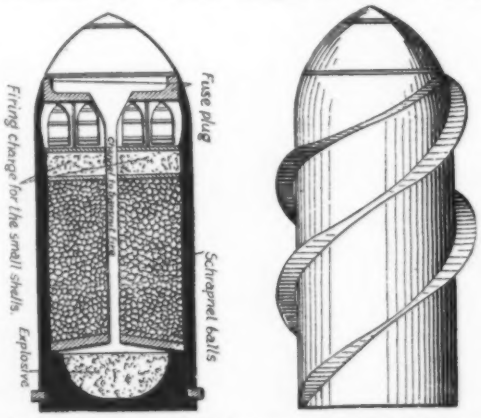

Fig. 3. Brust projectile for use on masked batteries

their power; but this is on condition that it is not produced until the very moment it is to be employed, i. e., at the instant the shot is fired and this is precisely what the Austrian invention has accomplished. The explosive charge accordingly presents not the slightest preliminary danger since it is composed of carbide of calcium (which as we know produces acetylene when in contact with water) placed in a special device which prevents the decomposing liquid from operating until after the discharge, and under the thrust of the gases proceeding from the firing charge.

This system is composed of a tube traversing the shell from one end to the other along its axis, from the base to the ogive; the part nearest the ogive is perforated for a certain distance and traverses a receptacle containing water, which, passing through the perforations, fills it; the part which ends in the base, to which it is fastened in a socket, contains a piston with water tight groves and segments, one of whose faces is in contact with the water which fills the tube while the other rests against a lock-spring placed at the base of the said tube (Fig. 6).

The partition of the receptacle which the tube traverses is conical and is formed by a series of segmentary elements which touch each other and are soldered together along their radial edges so as to constitute between them lines of rupture suitably distributed around the tube and capable of holding firm until a given pressure is attained.

The axial tube, between the receptacle and its extremity inserted in the base of the shell, is surrounded by an annular basket having perforated walls and containing carbide of calcium; one end of this basket (towards the top of the accompanying illustration) has the shape of a funnel, and is also perforated corresponding to the wall of the receptacle for water which lies opposite it. Furthermore a certain amount of empty space is left between the internal cylindrical wall of this basket and the corresponding external wall of the axial tube of the projectile, as well as between its conical (or funnel shaped) portion and that of the receptacle.

The socket at the base of the axial tube consists of a nut screwed into the base, and provided with perforations which establish a communication with the exterior. Any increase of pressure on the exterior will, therefore, be felt in the tube, and will exert its action upon the piston which this contains. This is what happens when the shot is fired. The pressure of the gases produced by the powder in the bore of the gun passes through the perforations of the nut and acts upon the rear surface of the piston, causing it to exert pressure upon the water contained in the tube; this water being forced in excess and with sufficient violence into the receptacle, which is already almost completely filled with water, provokes the explosion and the bursting of the cone. All the water in the receptable passing through the holes is then projected into the central portion of the basket and wets the calcium carbide, which immediately undergoes spontaneous decomposition. The acetylene formed becomes very rapidly compressed, attaining a very high pressure in a few seconds; this results in such a great degree of heat of the gas that it is dissociated and ignited giving birth to an instantaneous wave of a bursting power comparable to that of the majority of the explosives now in use.

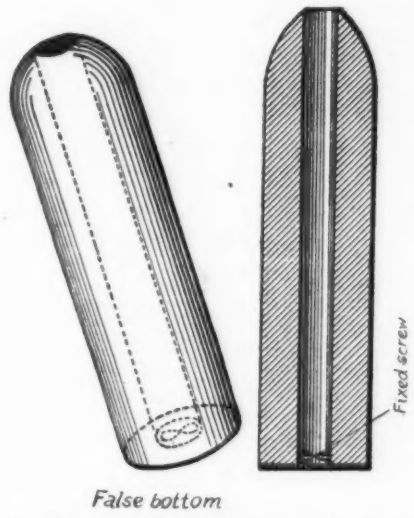

Fig. 4. Projectile for smooth bore guns. The false bottom drops off when the shot leaves the gun

The dangerous effects which the water might produce by reason of an accidental shock during the transport or manipulation are annulled by a lock-spring placed in the tube beneath the piston, which acts as a shock absorber, permitting more than sufficient expansion of the water without altering the tightness of the reservoir which holds it. It appears to be certain that some of these curious projectiles have been constructed and even experimented with, but it cannot be stated positively that they have been employed during the war.

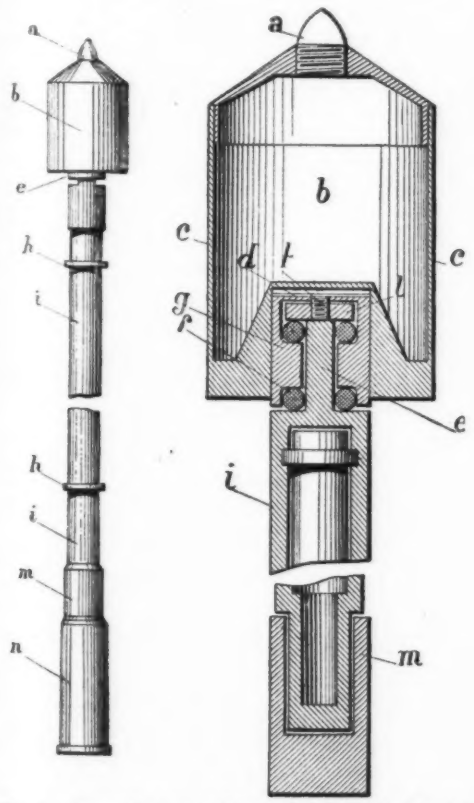

Fig. 5. General view and section of a projectile that carries with it a bomb

a, armed point of ogive;
b, chamber of bomb containing explosive;
c, body connecting bomb and projectile;
d, rubber cushion designed to absorb shocks on body c;
e, contracted portion of connecting rod revolving in ball bearings;
f, balls;
g, bearings;
h, rifling bands of connecting rod imparting movement of rotation by reason of the riflings in the bore of the gun;
l, nut;
m, rear portion of connecting rod introduced into socket;
n, socket which contains the firing charge and which is inserted into the barrel of the gun.

Vulcanization without Sulphur by Ostromyslenski's Method

In his experiments on the vulcanization of rubber by means of such substances as mono-, di-, and trinitrobenzene, Ostromyslenski made no quantitative measurements of the physical properties of his products. In the experiments here reported the progress of vulcanization was followed by breaking-stress and extension tests. Preliminary experiments in which raw rubber was heated with nitrobenzene and *m*-dinitrobenzene at 147° C. for 30, 60, or 90 minutes gave negative results, and even in presence of such organic accelerators as "acceleren" (*p*-nitrosodimethylaniline) and "vulcazite" (a condensation product of ammonia and acetaldehyde) no vulcanization occurred. Different metallic oxides, however, were found to act as catalysts towards rubber and nitro- or *m*-dinitrobenzene, and in all the subsequent experiments lead oxide was used. Experiments were made on two varieties of rubber, a quick vulcanizing smoked sheet with a vulcanization coefficient of 4.5, and a slow vulcanizing first latex crepe with a coefficient of 2.6. Nitrobenzene was found to have poor vulcanizing properties, *m*-dinitrobenzene giving much better results. In both cases the smoked sheet was vulcanized by the organic agent more quickly than the crepe, just as when sulphur is used. There are exceptions, however, cases being known in which the sample which is vulcanized the more rapidly by sulphur is affected less readily by dinitrobenzene. The time factor is important, for if heating is continued beyond a certain length of time the physical properties of the sample deteriorate. Thus 100 parts of smoked sheet heated with 8 parts of lead oxide and 4 parts of *m*-dinitrobenzene at 147° C. showed the best results after 10 to 15 minutes. The velocity of vulcanization is also increased by increasing the proportion of catalyst and of vulcanizing agent within certain limits. Between 137° and 157° C. the velocity of the reaction increases markedly with rising temperature. The quality of the rubber vulcanized with *m*-dinitrobenzene deteriorates rapidly; after a month a sample had become quite soft, although it was still insoluble in benzene. The samples also become gradually coated with crystals of dinitrobenzene. Attempts to prepare hard rubber by prolonged heating of raw rubber with lead oxide and dinitrobenzene failed. A soft leather-like substance was obtained which gradually extruded crystals of *m*-nitraniline. Attempts were made to vulcanize rubber by heating with inorganic oxidizing agents such as arsenic acid, potassium persulphate, bleaching powder, potassium bichromate, permanganate, chlorate, nitrate and ferricyanide, and manganese dioxide. In each case vulcanization appeared to commence but the products were unsatisfactory, although better than those obtained by use of mono- or dinitrobenzene without the addition of lead oxide. The addition of *m*-dinitrobenzene to a benzene solution of rubber increases the viscosity of the solution in the dark at ordinary temperatures, and more so at 65° C. Under the influence of light, however, the viscosity rapidly falls. It is concluded that the vulcanizing action of dinitrobenzene is due to an acceleration of polymerization of the rubber. Sulphur acts in the same manner, but at the same time forms a chemical or physical compound.—*Note in Jour. Soc. Chem. Ind. on a paper by E. Bunschoten in Kollard. Zeits.*

New Process of Spraying Metal

In a recent issue of the *Zeitschrift fur angewandte Chemie* is described a process for spraying metals on to any kind of surface, using metal melted in an electic arc and blown by means of gas-jets on to the surface to be covered. The metal to be sprayed forms one of the electrodes of the arc, and the gas-jets are directed so as to strike the sides of the metal electrodes without impinging on the arc and blowing it out. If the arc is produced between two electrodes, one being metallic, and a stream of non-oxidizable gas is directed on to the electrode, portions of the electrode that are melted will be carried away in the form of a fine spray, and may be deposited on any surface on which they impinge, thus forming a metallic skin on it. Suitable control apparatus is provided to allow for the wear of the electrodes.

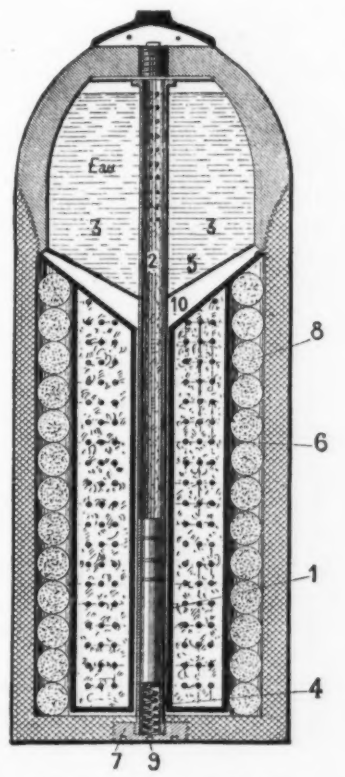

Fig. 6. Acetylene projectile

1, piston with watertight segments and grooves;
2, axial tube perforated in the portion which passes through the receptacle;
3, water container;
4, safety spring;
5, conical wall of container, capable of bursting at a given moment;
6, openwork basket containing calcium carbide;
7, nut of axial tube at base;
8, shrapnel balls;
9, perforations in nut forming communication between the axial tube and the exterior;
10, empty space in form of funnel above the basket.

Aeroplane Accidents*

Their Medical Aspect and Their Various Causes

By H. Graeme Anderson, M.B., Ch.B., F.R.C.S., Temporary Surgeon R.N. (attached Royal Naval Air Service); Senior Assistant Surgeon St. Mark's Hospital, London, and to the Belgrave Hospital, London

In the early days of flying there were necessarily many accidents, owing first to structural weaknesses in the aeroplanes, and secondly to the fact that the pioneer pilots had to experiment and were mostly unacquainted with many of the factors governing aerial navigation. When man began to teach man, and as improvements in the construction of aeroplanes increased, so accidents diminished in number proportionately; but, on the other hand, many more took up flying and the total of accidents was increased. The pre-war methods of teaching were slow and sure, and first solo flights were made in stages, and after prolonged tuition, thus tending almost to obviate accidents altogether. As the war advanced and the importance of aviation was recognised more pilots were needed, and the methods of teaching had to be accelerated; after a few hours' dual-control instruction pupils were sent off to do their first solo flights. Naturally many more accidents occurred, and as nowadays tuition is on faster and more powerful aeroplanes, so have the total number of accidents increased. Every accident teaches something new, and all should be investigated thoroughly, so that a preventable cause of error can be eliminated in the future. In this connection the reports of the Public Safety and Accidents Investigation Committee of the Royal Aero Club are very instructive and should be studied.

The total number of accidents due to school work and experimental flying is greatly augmented by the number due to war flying, either the result of aerial duels or anti-aircraft fire from the ground.

An attempt has been made to classify accidents at this station covering a period of six months, and these are referred to as the "V" series. In a general review of accidents, I have also drawn from fifteen months' experience while at another school, and these are referred to as the "E" series.

In the "V" series during six months 4,000 hours' flying were done, consisting of 9,000 flights, and during the time 58 aeroplanes were wrecked or crashed. The suggested definition of a crash is an aeroplane so damaged in a flying accident that it has to be deleted or sent into the workshops for repair or rebuilding. This is in contradistinction to the effects of a bad landing or get-off where the ensuing damage is small and can be repaired by the flight mechanics. Fifty-eight crashes in 9,000 flights represents one crash in every 155 flights. In these 58 crashes 16 airmen were injured, which is equivalent to 28 injuries in every 100 crashes, or one pupil injured in every 500 flights.

From these figures one can see that school flying is fairly safe and compares favorably with other high velocity forms of transit.

The tabulated record shows a greater frequency of crashes on the first and second solos, then a diminution from the third to the sixth inclusive, and a rapid rise again on the seventh. The inference suggested is that by the time the pupil arrives at his seventh solo he becomes over-confident and a little careless.

CAUSES OF AEROPLANE ACCIDENTS.

The causes of aeroplane accidents are: (1) defect in the aeroplane; (2) error in judgment in flying; (3) "loss of head"; (4) brain fatigue or lethargy; (5) fear; (6) physical illness; (7) unavoidable causes.

1. DEFECT IN AEROPLANE.

This implies mechanical failure of some part of the aeroplane, and can be subdivided into (*a*) breakage in the air and (*b*) engine failure.

(*a*) *Breakage.*—In the early days of aviation breakage or giving way in the air of some vital part of the aeroplane—for example, the folding back of a wing—was fairly common, and was due to faulty design or weakness in construction. Happily, to a great extent this has been corrected, and at the present time very few accidents are due to this cause. In three years' experience with the R.N.A.S. I have not seen a machine actually break in the air. In one case in the "E" series an elevator control wire jammed and caused the aeroplane to nose-dive, with fatal results to both occupants.

(*b*) *Engine Failure.*—Engine failure *per se* may be a direct cause of an aeroplane accident—for example, if the engine fails just as the aeroplane is leaving the ground and there is unsuitable landing ground the pilot may not have sufficient height or air space to avoid obstacles in front. Or in landing, the pilot may find in his glide downwards that he has undershot or overshot the mark and his engine will not "pick up" or respond to carry him on further to suitable landing ground.

On the other hand, engine failure may not be a direct cause, but may be a strong contributory or indirect cause of an accident. In all cases if the engine fails in the air a forced landing is compulsory, but given a fair height—2,000 feet or more—the pilot can usually select a good field for landing and arrange his descent accordingly. Of course, on approaching the field to land it may be found not quite so good as imagined from a greater height—for example, sloping ground, long grass, etc.—and thus the pilot may make an error of judgment on actually landing. This quite often occurs with a pupil, but rarely with an experienced aviator, who knows exactly how to "pancake" his machine. But even in the case of experienced aviators engine failure just after leaving the ground is a strong contributory cause to the real cause of an accident—namely, an error of judgment in flying. Authorities cite as one of the commonest examples of aeroplane accidents engine failure just after leaving the ground, when the pilot tries to turn back to his original starting-place, loses height in the turning, and, in trying to prolong his glide, loses flying speed—stalls—and the aeroplane falls to the ground out of control. In the "V" series engine failure was the direct cause in one case and was a contributory cause in two cases.

2. ERROR OF JUDGMENT.

Error of judgment in flying is the commonest cause of aeroplane accidents. This error may occur in getting off the ground, in the air, or on landing.

Of the 58 crashes in the "V" series this cause accounted for 42—4 in getting off the ground and 38 on landing. Of the many examples of error of judgment in flying perhaps the commonest is when, on landing, the pupil misjudges his distance from the ground and either "flattens out" too soon and "pancakes," with a possible crash depending on the height, or else "flattens out" too late and strikes the ground at a varying angle, usually overturning and wrecking the machine. Other examples in the air are putting on too much "bank" with insufficient "rudder," or *vice versa:* climbing on a turn; and, as in engine failure, prolonging a "glide" so that the machine loses flying speed.

It is difficult to estimate and account for these errors of judgment. In some cases it may be due to under-instruction. In other cases, even after prolonged instruction, the pupil may still misjudge distances, and on examination one occasionally finds that his standard of vision is below normal; but, on the other hand, he may be found physically fit, with normal vision and good balancing power. In the latter cases it may be a question of delayed reaction time, especially the visual reaction time on which the aviator is so much dependent. Normally this reaction time takes 19/100ths or 20/100ths of a second. It may be delayed by fatigue, drugs, and excesses; but, on the other hand, in some individuals who are otherwise physically fit it is found to be much slower than in others. Hence, in the selection of candidates for aviation the visual and other reaction times must be up to the normal standard. By the French medical authorities on aviation, candidates are rejected if the reaction times are found to be of the delayed type.

3. LOSS OF HEAD.

Loss of head occurs fairly frequently in a greater or less degree and accounts for a fair proportion of accidents—seven in the present "V" series. The pupil in his new occupation of flying for the first time has all his mental faculties on the alert, at extreme high tension; the sense of danger, although not asserting itself, is ever-present, but subconscious. Under the sudden strain of an emergency his power to reason and act synchronously may momentarily lapse, resulting in what is known as loss of head. In a critical position the pupil has to think, decide, and act quickly, but with loss of head the mental balance becomes upset; there is no mental inertia, but the wrong decision is taken and acted on. In flying, seconds and parts of a second count enormously, and may mean all the difference between safety and danger. After actual loss of head there is seldom time to correct the error made. As examples of loss of head in the air the pupil in an emergency may move the throttle the wrong way, may keep his engine full on when he should throttle down, or may switch off his engine at a moment when he requires all the flying speed possible. Loss of head is very much allied to the two following causes:

4. BRAIN FATIGUE.

In contradistinction to loss of head, the pupil in brain fatigue reaches the stage where he has neither the power to reason, decide, nor to act. A state of mental inertia supervenes. This is due to repeated stimuli received by his brain in rapid succession in his flight—he feels alone; a succession of errors occur in the air; he feels he cannot manage to control the aeroplane; fear does not seize him, but the enormity of the whole thing appeals to him; he feels helpless, and a state of brain fatigue occurs in which he, in a stupor, awaits events and takes little part in the aeroplane's control. After a careful study of 100 of the first solo flight confessions of pupils, and of many pupils who have had crashes, I am convinced that brain fatigue is â cause of a fair proportion of accidents. Four occurred in the 58 of the "V" series. As a rule in brain fatigue the pupil fails to flatten out, and the aeroplane strikes the ground at its gliding angle and becomes wrecked. On questioning a suspected case of brain fatigue immediately after his flight one finds usually that there is very little recollection of what happened during the flight; memory seems to become partially stunned. It is difficult to make a diagnosis of those liable to brain fatigue. As a rule, if it occurs, the pupil, even should he escape injury, soon gives up flying. He is not of the temperament suitable for flying. As a preventive the pupil's first few solo flights should always be of short duration.

5. FEAR.

Fear, at least in a degree sufficient to disturb one's flying, is rarely experienced in the air on the first few solo flights, whatever the sensations may be before going up or in the intervals between flying. The mind is far too much occupied and concentrated on details of flying, watching the various instruments that record air speed, height, levels, and engine's revolutions, and in judging position and direction in the air relative to the ground. From an analysis of the confessions of the first solo flights of 100 pupils and of my own it is curious to note that very few experience fear in the air, at least not in a degree sufficient to disturb flying. Many confess to a sense of danger lurking somewhere at the back of the head, but say that it rarely if ever asserts itself. In the "V" series no crash occurred through fear.

6. PHYSICAL ILLNESS.

In the series of crashes under consideration none was attributable to physical illness. At an air station medical inspection of the pilots and pupils at regular intervals reveals any organic disease that might lead to loss of consciousness in the air.

Flying on an empty stomach may cause faintness in the air. In schools flying commences at dawn, and all pupils are provided with a good meal of cocoa, tea, and bread-and-butter. Similarly on long flights pilots are provided with tabloid forms of nourishment. The effects of cold and fatigue may produce faintness or stupor in the air. There are many instances on record of pilots fainting in the air either through being wounded or from high altitude effects. Some have been known to recover consciousness before reaching the ground and to make successful landings. Two pupils in the "E" series suffered from attacks of malaria in the air and both were made to discontinue flying. Another pupil in "E" series, although slow to learn, was making fair progress, but one day he was noticed to descend rather steeply; he made no attempt to flatten out, the aeroplane struck the ground at its gliding angle, and the pilot was thrown out, clear of the machine, a distance of 66 feet, and escaped with only a slight sprain of one ankle. A few days later in the ward-room this pupil was seized with a series of typical epileptic fits. On inquiry a history of epilepsy for the previous five years was elicited. This was undoubtedly a case of an epileptic fit taking place in the air.

7. UNAVOIDABLE CAUSES.

From time to time unavoidable accidents arise. Every precaution is taken at a flying school to prevent collisions in the air or on the ground. Set signals are made with regard to the direction of circuits and landing areas for different flights. The terrain in certain areas may be unsuitable and conceal obstacles; again, in some aeroplanes the view of the sky or

*Abstract of an article published in the *Journal of the Royal Naval Medical Srevice.*

ground in certain positions may be limited. These conditions may cause unavoidable accidents. In the "V" series four accidents were unavoidable. Two were due to bad terrain with obstacles concealed in the grass; in the case of the other two a collision took place in the air.

TYPE OF ACCIDENTS.

The term "type of accident" has been suggested to describe the part of the flight in which the cause of the accident was initiated. It is possible to make an arbitrary division of a flight into three part: First, the getting off the ground into the air up to 50 or 100 feet; second, in the air, with the various turns, figures of eight, climb, spirals, etc.; and, third, the landing, which includes the descent from the time the throttle is closed to the time the aeroplane is brought to a standstill on the ground.

Some of the errors which the pupil may make in getting off are raising the aeroplane's tail too high, slewing to one side, or getting off with one wing down. In the air a pupil may lose flying speed or stall, or may sideslip or spin. The commonest type of accident is in landing—the pupil's *bête noire*. He may either flatten out too soon, lose flying speed some feet from the ground, and the machine "pancake," or else he may be too late in attempting to flatten out, and the aeroplane strikes the ground at an angle, turns over, and is wrecked.

SOME FACTORS RELATIVE TO AEROPLANE ACCIDENTS.

The injuries sustained are akin to most high velocity acidents, but are usually more severe, as greater speed is used in aviation. They are composed of—

1. Injuries due to crushing, where some part of the pilot's body gets crushed between parts of the wrecked aeroplane. Crushing injuries are very severe in nature and mostly fatal in the propeller type of aeroplane (engine behind).
2. Injuries due to collision with the ground, as when the pilot is thrown out or hits the ground with his head in turning over in and with the aeroplane.
3. Injuries due to impact with different parts of the aeroplane, as when the head is violently jerked forward and strikes the edge of the nacelle on the aeroplane's impact with the ground. Flying débris, such as broken struts and wires, may cause local impact injuries.
4. Injuries from fire.
5. Drowning and immersion effects in seaplane work.
6. Suspension effects, as when the pilot is suspended head downwards in an overturned aeroplane and is unable to loosen his safety belt. In many crashes the sudden impact of the pilot's body on the safety belt causes abdominal injury.

The injuries sustained vary a good deal, and depend on the type and power of the aeroplane and the cause and type of accident. An experience of three years attached to the Royal Naval Air Service impresses me more and more with the element of luck which befalls pilots in crashes. The present-day school aeroplane is much stronger in construction and more powerfully engined than in earlier days, thus providing for a greater margin of error on the pupil's part. The propeller type of school machine (for example, the Maurice-Farman) is considered very safe. It can be landed slowly, and has a powerful engine to cover errors. In a crash it has a strong undercarriage and a great deal of woodwork to absorb the shock before actual injury occurs to the pilot. On the other hand, in a nose-dive in this type of machine the engine, being behind, is likely to crush the pilot severely, and this usually proves fatal. In tractor machines the engine in front takes most of the shock in a crash, but the observer's seat just behind the engine usually gets telescoped or crumpled sideways. The pilot's seat, which is behind these, usually escapes crushing effects. If the pilot receives injury, this occurs either from his being thrown out or from his head being violently jerked forward and hitting the nacelle edge, windscreen, or instrument board. Should the safety belt hold, the sudden impact of the pilot's abdomen and lower part of chest against it may cause internal injuries. Nowadays most nacelle edges are padded, and safety belts are stronger and broader.

SAFETY BELTS.

With regard to the use of safety belts, endless discussion has taken place among aviators. My own opinion is that before leaving the ground all aviators should see that their safety belts are fastened and should be familiar with the method of their quick release. The belt should never be undone in the air. Thus the pilot, in the event of fainting, losing consciousness, or being wounded, or encountering gusty and bumpy weather or fog, has a safeguard to prevent him either being thrown out in the air or thrown forward on to his control lever (thus causing the aeroplane to nose-dive), or having his feet jerked off the rudder bar (thus losing steering power). I think all are agreed on the above, but the difficult question arises whether to release the belt near the end of a glide before landing. This I would advise in the propeller type of aeroplane, but in the tractor machines it remains an open question.

Certainly if the aeroplane catches fire in a crash little hope can be entertained of the pilot if he be strapped in. Safety for him depends on his being thrown out clear of the machine. A narrow belt is to be condemned. The ideal safety belt should be broad and resilient, attached to the framework of the aeroplane and not to the pilot's seat, should be made to release easily and quickly, not at the centre of the pilot's body but at the side where it is attached to the aeroplane. This release should be effected by means of a small hand lever. It is advisable for all pilots to carry a stout knife in the outside pocket of their flying coat in order to cut the belt should they be held in upside down after a crash.

SAFETY HELMETS.

These are of undoubted value in school work and should be worn by all pupils. They should fit properly and not be easily dislodged while flying. The modern ones are much lighter and less high in the crown than the earlier ones used. In a crash they certainly prevent scalp wounds from broken struts and wires, and the side flaps protect the ears from injury. Over and over again I have seen pilots thrown out who owe their escape from more or less serious head wounds to their safety helmets.

On the other hand, in a turn-over, the added height of the crown may catch the ground and wrench the head either forwards or backwards, causing fracture, dislocation of the neck, or severe strain and possible rupture of the muscles of neck and back.

As pointed out by Fleet Surgeon Wells, an ideal safety helmet would take its support from the shoulders.

GOGGLES.

Most aviators wear goggles, but there are still some who prefer to fly without them. I know of one instructor who, after a year continuously instructing pupils and wearing no goggles, began to suffer from a form of conjunctivitis. I certainly think that goggles should always be worn. There is no doubt that flying without goggles is apt to set up a spasm in the eyes which in the long run is bound to do harm. Triplex or non-splintering material is now almost universally used instead of glass in the manufacture of aviation goggles. Thus rarely in a crash do we get any injury to the eyes. The nose-piece connecting the two lunettes should have no metal in its composition. I have seen some cases where wounds of the nose were caused by the metal connecting part of the lunettes.

ACCIDENTS UNDER DUAL CONTROL.

Accidents under dual control are not common, as the instructor has usually time to correct in the air any of the pupil's errors in flying. One occurred in the "V" series, and was unavoidable owing to the character of the ground. In the "E" series three occurred. All dual control machines should be fitted with a mechanical device for throwing out of action quickly the pupil's control of the machine. I have seen three other crashes under dual control but without injury to either instructor or pupil.

FATAL ACCIDENTS.

In two years of school work I have only seen three fatal accidents occur in roughly 200 crashes. Four deaths occurred, of which three were instantaneous and one after four days. All were due to multiple injuries.

The Principles of Diffusion and Their Analogues*

THE standpoint from which Professor Horace T. Brown, F.R.S., of London, first approached the Principles of Diffusion, their Analogies and Applications in a lecture, delivered before the Chemical Society, was that of the physiological chemist. The outcome of the lecturer's many years of experimental and theoretical study of the phenomena of diffusion is, however, that the plant inhales the carbon dioxide of the air just as a solution of caustic potash absorbs this gas, that as regards diffusibility of gases and liquids physiological processes follow physical laws, that the diffusion and evaporation curves bear a striking resemblance to the diagrams illustrating the transmission of heat through thin lamina, equipotential shells surrounding electrically charged bodies, magnetic and hydraulic stream lines, etc., and that all these problems admit of similar mathematical treatment. The statement may still surprise chemists as Nernst did in 1904, when he said that determinations of the velocities of reactions taking place at the boundaries of heterogeneous systems might entirely be vitiated if diffusivity were not taken into consideration as a limiting factor. Though a few of Professor Brown's analogies may look more apparent than real in their brief statement, his lecture was of the greatest interest, and it will probably be news to our readers *e. g.*, that the closing of a port by a perforated diaphragm will hardly impede the diffusion of gases through the ports, though the diaphragm may block 90 per cent. of the area of the cross section, leaving only 10 per cent. of open-perforation space.

The problem that confronted Professor Brown in his photosynthetic studies 20 years ago was the following: The animal inhales the oxygen of the air and exhales carbon dioxide into the air. The plant inhales the carbon dioxide and lives on it largely, building the manifold organic compounds up from the carbon of the CO_2. The inhalation takes place through the stomata of the green leaf, minute apertures in the cuticle of the leaf. Now the cuticle is impervious to CO_2—at any rate at the very low partial pressure of the 0.03 per cent. of CO_2 usually present in the atmosphere—and the stomata do not represent more than 3 per cent. of the leaf area at the best. Yet the leaf assimilates CO_2 at more than half the rate of a surface of concentrated caustic soda of the same area as the entire leaf. That means, that the minute apertures can drink in CO_2 at about 50 times the rate that the same apertures could do if they were filled with continuously-renewed caustic alkali. How is this possible?

The historical sketch of the development of the diffusion problem may also cause some surprise. The study of diffusion is generally coupled with the name of Thomas Graham. But though Graham experimented on diffusion through plugs of plaster or thin plates of graphite, and later in open jars, from 1826 till 1863 (he died in 1869) he hardly made any quantitative determinations of diffusion coefficients, which Loschmidt first deduced from Graham's last experiments, and he did not attempt to formulate any general law as to the three variables: time, concentration, space traversed by the diffusate.

Incidentally Professor Brown remarked that, though Graham was Professor at University College and for some time president of the Chemical Society of London, English chemists did not take up this research which still receives but scanty treatment in text-books. Unknown to Graham, A. Fick, of Zürich, formulated the law of diffusion as early as 1855. Like Ohm's law, Fick's law was deduced from the principles enunciated in Fourier's Analytical Theory of Heat which Kelvin described as a great mathematical poem. If the two parallel surfaces of a plane lamina of thickness x and area A be kept at temperatures Θ_1 ond Θ_2, then the quantity of heat Q passing through the lamina in time t is $Q = k\ (\Theta_1 - \Theta_2)\ A\ t\ /\ x$, where k is a constant numerically equal to the quantity of heat which will flow through unit area and unit thickness in unit time, when there is unit difference of temperature. For a small $d\ x$, $Q = k\ A\ .\ d\ t\ .\ d\ \Theta\ /\ d\ x$ where $d\ \Theta\ /\ d\ x$ is the temperature gradient. Fick argued that diffusion, the transference of a solute in its solvent, should follow the same law as heat, as it did in the case of the flow of electricity, so that temperature, concentration of the solute and electric potential were analogous, and that for regular flow along a diffusion column of constant cross-section (cylindrical or prismatic) the concentration gradient corresponded to the temperature gradient. Thus the differential equation would hold: $d\ p/dt = k.\ d^2\ p/d\ x^2$, where p indicates density, and k represents the coefficient of diffusivity, which, subject to certain limitations to be pointed out, is constant for any solute or solvent as long as the temperature remains constant. Hence, Fick stated, the transfer of water and salt between two elements of space with differently-concentrated solutions should be directly proportional to the difference of concentration and inversely proportional to the distance between the elements of space.

Fick's own experimental verification of his law did not go very far, but the law has since been verified by optical, chemical and electrical methods. The most satisfactory of these verifications is due to Weber, the collaborator of Gauss, who, in 1879, proved the measurement of the electromotive force between electrodes of zinc and copper immersed in solutions of their sulphates, can be utilised for exact determinations of the concentrations of these solutions at their boundary surface. Stefan proved the law in 1879 from Graham's last data. A complete theory of diffusion from the kinetic point of view is still extant. But the law of Fick or Fourier enables us to solve all diffusion problems with fair approximation. Slight deviations from it may be due to the fact that the k is not constant, but dependent upon the partial concentrations of the constituents in mixtures, though Professor

*Engineering.

Brown himself failed to obtain distinct evidence of this influence. Dissociation would also affect diffusion, a point to which Professor Brown merely alluded. It was for this reason, however, that Fick's law was often quoted in the early days of the electrolytic-dissociation controversy, while it is very rarely referred to now. The diffusive efficiency is expressed by $Q = k.\ At\ (p - p_1)/L$, where L is the length of the column. For a cylindrical or prismatic column or bar, the diffusive flow is analogous to thermal flow, apart from the heat emission from the surface, and analogous to the steady flow of electricity along a conductor, in which case the coefficient of diffusivity k corresponds to electric conductance, and the surfaces of equidensity correspond to equipotential surfaces. When the column is not of uniform cross-section, the stream lines of Hele-Shaw and the lines of force of Maxwell still provide the analogy. A single sphere, electrically charged, is surrounded by concentric shells of equal potential, and the relative nearness of these shells (or circles, in sections) indicates the density gradient of the charges at points situated on the shells. The lines are more crowded near the sphere than further away. When two such spheres of unequal diameters, charged to the same potential of the same sign, are near one another, a system of oval or lemniscatic lines surrounds the two spheres; the lines are more crowded (and more curved, of course) near the smaller sphere, and there is between the two spheres a point of equilibrium.

These phenomena can easily be illustrated by the aid of salt solutions, especially such as give colored precipitates, and columns of jelly (agar or gelatin) confined in glass tubes. When the jelly containing a little barium chloride is immersed in an alkali chromate solution, the advancing precipitate of the barium chromate arranges itself in bands of decreasing color intensity and increasing width. When the jelly is colored with Congo red and immersed in hydrochloric acid, the depth to which the acid has penetrated is marked by the change of the red into blue. The experiments become more striking still when conducted after Liesegang; two holes are formed in a layer of jelly which is impregnated with the one chemical reagent; a solution of the other reagent exudes through these holes, and the reactions produce in the jelly a rhythmical series of light zones and darker rings, resembling the banded structure of certain agates. When the two holes are not of the same diameter, the chemical diffusion analogous of the case of the two electrically-charged spheres, and the dead spot of no precipitation can also be seen. Spots of ink or of colored salt solutions on blotting paper afford still simpler illustrations of the diffusion phenomena; in that case, however (a fact which Professor Brown did not mention), capillarity plays an important part, but capillarity is probably concerned in the jelly experiment also. When a tube, containing jelly and some barium chloride and open at both ends, is placed horizontally in sulphuric acid, so that the acid can enter the jelly from both ends, the precipitation of barium sulphate progresses equally from both ends, but a narrow central portion of the tube always remains clear of the white sulphate. That is because the acid and the salt diffuse in opposite directions, the one inward, the other outward, and because the central space is depleted of salt or of barium ions before the acid reaches it. Professor Brown considers this neutral central spot analogous to the node of acoustical experiments with an oscillating air column, the dead space in the tube corresponding in position to the node. As there are no oscillations in the diffusion experiment, the analogy seems to be merely apparent. But the two problems may admit of the same mathematical line of attack, and it is certainly interesting that Professor Brown has also been able to imitate the well-known figures of Chladni, the figures in which lycopodium powder arranges itself when strewn on plates of various shapes which are thrown into acoustical vibrations. When inward diffusion takes place simultaneously from all the four edges of a square cover-glass, the four opposing streams of the reacting diffusate mark out regions of equilibriums in the form of a diagonal cross. In an equilateral triangle three dark lines are formed, extending from the centre of the triangle to the corners; photographs of other figures, suggesting also the structure of complex soap films, were exhibited by Professor Brown.

We turn to the very important problem of diffusion through conical apertures. With such tubes the flow is convergent or divergent, not parallel, and the density gradient is not uniform, but greater in the narrow than in the wide portion. Suppose we have a truncated cone, 10 cm. in length (or height), the smaller end of which has an area of 1 sq. cm. at a distance of 1cm. from the apex of the (complete) cone; then it can be shown that the diffusion flow through the cone should be eleven times greater than the flow through a cylindrical tube of the same length and of the uniform cross section of 1 sq. cm. As regards the mathematics of the phenomena, Professor Brown referred to Sir Joseph Larmor and Mr. R. A. Fisher, whose deductions have been confirmed experimentally.

It will now be recognised that this accelerated flow through conical tubes has a bearing on the breathing of animals; for in the bronchial tubes the interchange of gases depends on diffusions, and the fact that there are a large number of bronchial tubes close to one another is another important factor. When a septum, perforated by many small holes, is interposed in a system of parallel stream lines, the lines crowd when near and in the perforations and become parallel again further away. It is owing to this face, Stefan pointed out in 1881, that evaporation from a liquid surface takes place in divergent hyperbolic lines, the foci of which lie in the bounding edges of the surface, and that the evaporation is proportional to the linear dimension of the surface and not, as was assumed, to its area. The experimental proof of this was only given by Professor Brown and Mr. E. Escombe. Further, just as the electric capacity of a plate is not much affected by cutting portions out of it, so as to produce an open frame work, so it is possible also to block out a considerable portion of the cross-section of a diffusive column without materially affecting its diffusive efficiency, as we pointed out in our introduction. The effects of fine subdivision also fall under this consideration. When a sphere of unit volume is divided into 1,000 small spheres of equal volumes, the surface extension will be 10 times that of original sphere, but the diffusive efficiency will be 100 times greater. These considerations may account for the acceleration of the velocity of reaction by finely-divided catalysts, for the amazing activity of minute organisms, and for the effectiveness of the stomata of the green leaf in accelerating the absorption of CO_2 by the plant and in general the interchanges of gases and water vapor—the first-stated problem to which we finally return. Those stomata are minute truncated perforations which by their multitude make the leaf a more efficient absorber than caustic potash would be. The breathing stigma of a caterpillar are again of the same structure as the stomata, and the green leaf will not represent the only case of adaptation to the conditions most favorably to rapid diffusion. Diffusion is by no means always so slow as it was in Graham's open-jar experiments, when he found that carbon dioxide can diffuse through air at the rate of 7.3 cm. per minute, while hydrogen travelled five times faster.

There are many other points of interest in Professor H. T. Brown's lecture—which was published in the July issue of the Journal of the Chemical Society—and a careful study of it will prove most instructive. With the advance of our knowledge of physiology, the differences between the laws of biological and of general chemistry and physics vanish more and more completely, and the uniformity and universality of the laws of Nature stands out more clearly. But all that advance does not bring us tangibly nearer any explanation of the mystery of life.

Cadmium in Brass

As much of the zinc now imported into France contains considerable proportions of cadmium, Leon Guillet (*Comptes rendus*, March 6, 1918), has investigated the influence of cadmium on the mechanical properties of brass. He prepared alloys containing 70 to 60 per cent copper, 28 to 40 per cent zinc, and up to 4.54 per cent cadmium. The high percentage of cadmium is accompanied by a relatively high percentage of lead to which Guillet does not draw attention. The other impurities were iron and tin, neither present in more quantity than 0.1 per cent. He found that cadmium had little influence on the properties of the brass, as long as cadmium did not exceed 1 per cent, and higher percentages are fortunately rare. The influence of cadmium was distinctly deleterious.

It had the effect of lowering the hardness and general strength and this was particularly noticeable in the impact tests which were made on notched bars. The elongation was hardly affected as long as the cadmium remained below 2 per cent. For low percentages the cadmium could be traced in fine lines surrounding the grains of alloy; when the percentage went higher the cadmium was seen to be isolated in round grains. It would appear that the cadmium enters into solid solution when present in small proportions. The detrimental effects of the presence of cadmium were far more striking in an α than in an α-β brass.—*Jour. Ind. & Eng. Chem.*

A Platinum Substitute

An alloy containing about 11 per cent Pt and 89 per cent Au is being made under the trade name "Platino." Experiments show the alloy to be very resistant; it is, however, attacked by sulphuric acid containing nitric acid, but is more resistant to a caustic potash than platinum. On heating in a smoky flame, it does not become brittle, as is the case with platinum. Its resistance to fused potassium nitrate obviates the necessity of using porcelain vessels for fusions. The cost is about one-third that of pure platinum.—*Note from Jour. Soc. Chem. Ind. on a paper by I. L. B van der Marck in Pharm. Weekblad.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

Published by Scientific American Publishing Co.
New York, Saturday, January 11, 1919

Munn & Co., 233 Broadway, New York
Charles Allen Munn, President; Orson D. Munn, Treasurer
Allan C. Hoffman, Secretary; all at 233 Broadway

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 5.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Scientific American Publishing Co.
233 Broadway, New York

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